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NOVEMBER 1, 1987

Electronic Business®

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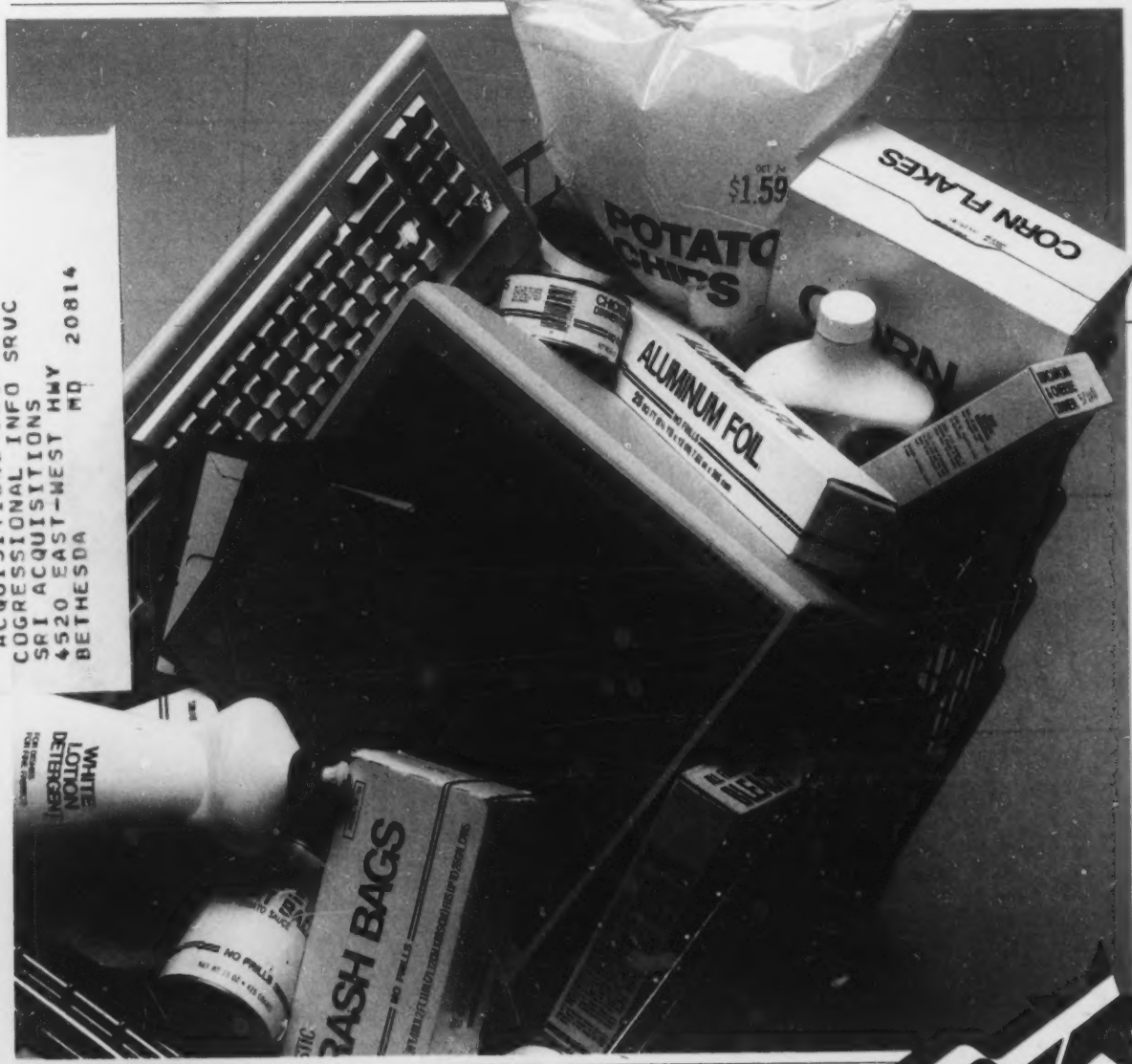
Analogic's Gordon: Turning engineers into managers PAGE 22



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Keeping America Competitive
Implementing JIT

VOL. 13, NO. 21

Electronic Business

NOVEMBER 1, 1987

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BPA ABP

Good sign: Distributors' shipments pass the 1984 peak

An even better sign: This time it took twice as long to get to the peak

The distribution shipments index, which the National Electronic Distributors Association compiles from a sample of its members that represents more than half the sales of industrial electronics distributors in the United States, peaked last June at a level of 2.24. (That is, 124% more than the index's base from May 1980.) This level is significant because it edged out the previous record of 2.23 from March 1984, a period which many electronics market watchers, and certainly many distributors, still fondly remember as the good old days for electronics activity in the United States.

Some, however, watching the level of shipments retreat during the summer, see a dark side to the significance of this peak. Is this the highest level the distribution business can attain, only to be followed by another drop in its roller-coaster pattern? Not to worry; for distribution sales attained those two peaks in very different ways. It took two full years for the shipments' index to climb from the recession's low point — 1.62 in July 1985 — to the recent high. By contrast, it took less than nine months last time for the index to cover similar ground, from 1.54 in July 1983 to 2.23 the following March.

The implication is that the current level of activity, while higher than in 1984, is on far more solid ground; but the fact is that shipments dropped during the summertime, along with a retreat in NEDA's book-to-bill ratio.

There are, fortunately, positive reasons for this decline. The book-to-bill ratio peaked last April at 1.12, a value that says orders are coming in ahead of shipments but at a far more manageable rate than they did in 1983-1984, when the ratio stayed uncomfortably above 1.20 for more than six months.

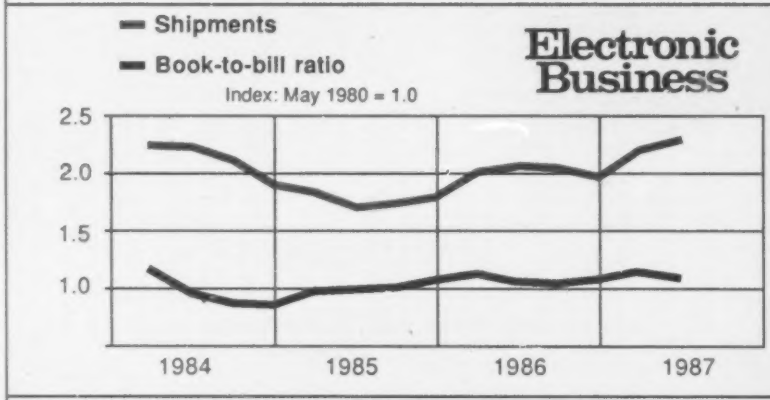
One factor which may have contributed to shaving a few points off the book-to-bill ratio is the increasing number of distributors offering just-in-time programs to their customers in an effort to keep those customers from going directly to components manufacturers for JIT supplies. From the customer's point of view, the immediate impact of a JIT program is that it reduces leadtimes.

Unfortunately, a side effect of JIT is that to maintain such a program, a distributor may be forced to build its own inventory. This happens when the components manufacturer is not very efficient or cooperative in holding up its own end of the JIT program, or simply does not want to participate if the volume is low. "The trend is for the manufacturers to give up the bottom 3% of orders," says Morton L. Mandel, chairman of Premier Industrial Corp. of Cleveland.

Encouragingly, profits for distributors are slowly returning after a long drought. The second quarter was profitable for the largest distributor, Avnet Inc., while its sales increased 12% over the year-earlier quarter; this matched closely the increase for NEDA's shipments index. More profitable, relative to their sales, were Premier Industrial, which showed a sales increase of 8%, and Marshall Industries, which recorded a 15% gain in quarterly sales.

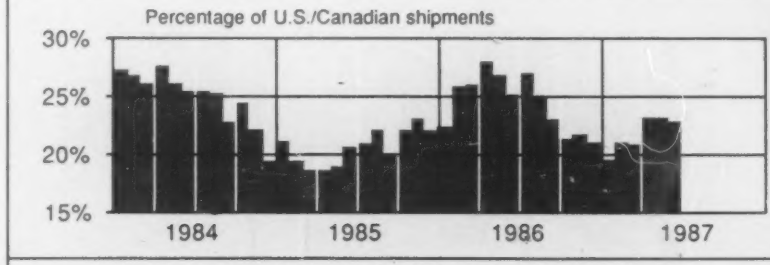
ALBERTO SOCOLOVSKY

Distribution business index



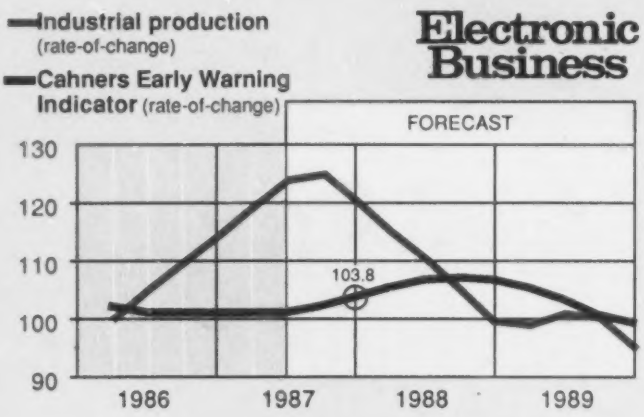
Source: National Electronic Distributors Association

Distributors' share of IC shipments

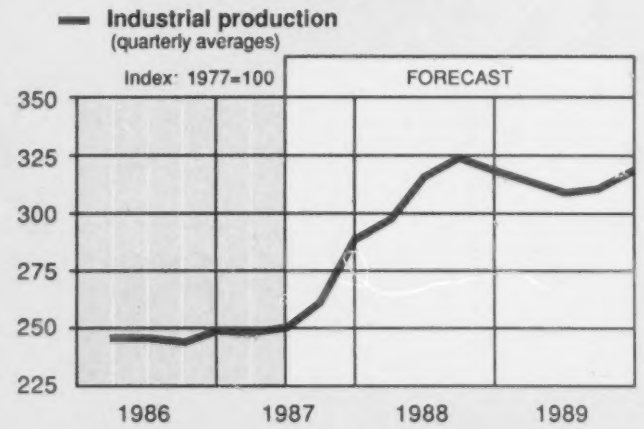


Source: Semiconductor Industry Association

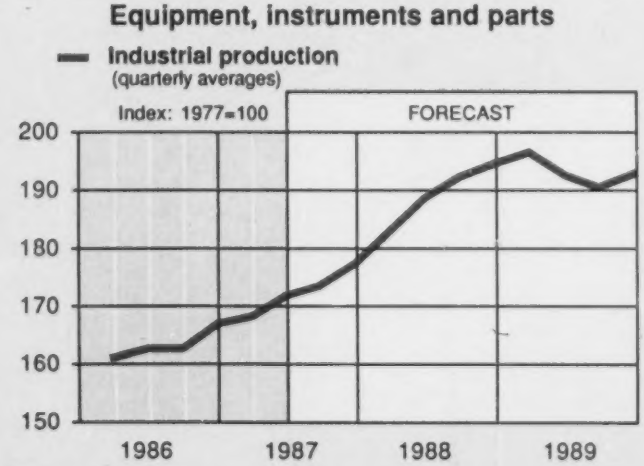
Economic indicators



Electronic components



Equipment, instruments and parts



Historical data: U.S. Commerce Department; Forecast: Cahners Economics

Steady growth expected

The United States Index of Industrial Production, a coincident indicator of the U.S. economy, has been climbing steadily since the summer of 1986. This spring, output rose 0.7%, according to estimates from the Federal Reserve Board. This slow and steady growth is expected to continue until next summer. Production is expected to rebound after a year and a half of sluggish growth pushing production up 6.8% in 1988.

The Cahners Early Warning Indicator has been adjusted by deleting the unusual effects of recent changes in financial markets. The adjusted indicator points to an upturn in the economic business cycle with the next business peak in August of 1988. This leading indicator, (CEWI) is a weighted average of housing starts, the Dow Jones Industrial Stock Index and the money supply (M2) — deflated by the Consumer Price Index, has proven to be an excellent forecasting tool. It forecasts the turning points in the economic business cycles about 12 months in advance. The black curve is a plot of the 12-month rate of change Index of Industrial Production. That is, its change over a 12-month period can be determined by comparison with the line at 100. For example, the 103.8 level forecasts using the CEWI for the end of this year indicates that the average for all of 1987 should be 3.8% above 1986.

More information can be obtained from Elizabeth Baatz, economist, Cahners Economics Department, 275 Washington St., Newton, Mass. 02158.

Equipment, instruments and parts

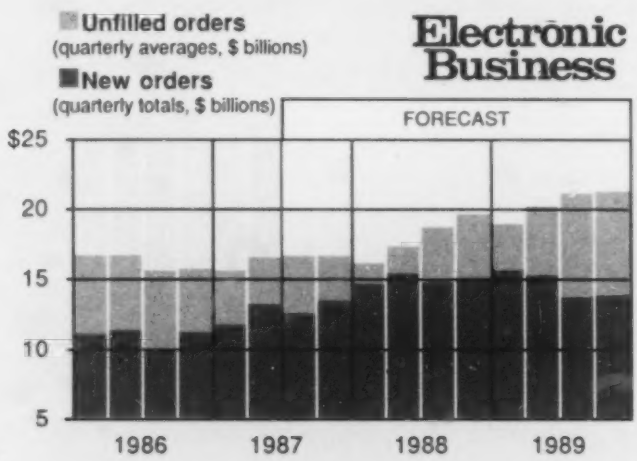
Production of scientific and engineering instruments jumped 6% in the second quarter from the year ago level. A quarterly growth rate like this has not been seen since 1984. Output is expected to pick up even more in the second half of 1987, leaving production for the year 6% above 1986's level. Increasing demand for more precise and automated instruments such as chromatographs, sensors and other measurement equipment is expected to boost production by 9.7% next year. In 1989, with industrial growth slowing, output should rise only 1.9%.

Electronic components

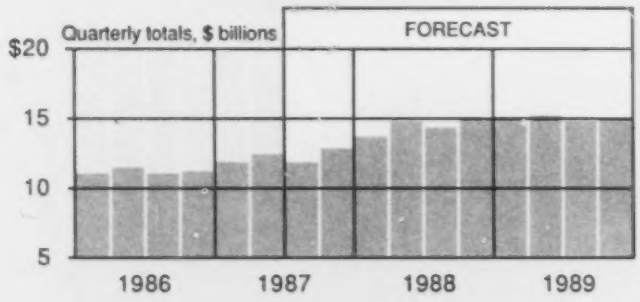
Electronic components output rose 0.8% in the second quarter of 1987, putting it 2.1% above the year ago level. The second half of 1987 should see a more substantial 11% gain. Next year is expected to be the industry's banner year, with component production growth of 20%, its best annual performance since 1984. By next summer, components output is expected to set a new record, rising 11% above its previous peak production level set in 1984.

Electronic components (SIC 367)

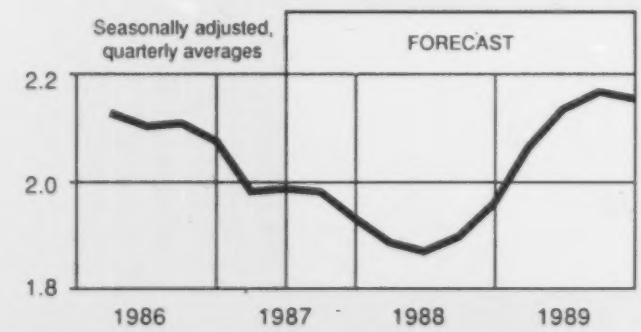
New and unfilled orders



Shipments



Inventory-to-shipment ratio



Historical data: U.S. Commerce Department; Forecast: Cahners Economics

New orders

Orders for electronic components surged 12% in the second quarter of 1987 to $13.1 billion. Despite some sluggishness in component production in early 1987, orders are up strongly over year-ago levels, which bodes well for the continued recovery in components. By the end of 1987, orders are likely to total $50.6 billion, 17% more than 1986. Next year an 18% gain in orders placed by domestic computer makers and export markets should put the components market back at record-breaking levels. A short and mild cyclical downturn is expected in 1989 when orders may dip 2.5% to $58.4 billion.

Unfilled orders

With new orders on the rise, backlogs of components are expected to soon begin rising sharply, mirroring previous business expansions. In June, unfilled orders reached just $16.5 billion, 6.5% above March's level, but unchanged from a year earlier. By the end of 1987, backlogs are expected to have gained another $100 million. Over the next two years, backlogs are expected to expand to $19.5 billion by the end of 1988 and $21.3 billion by the end of 1989.

Shipments

Shipments of components totaled $12.1 billion in the second quarter of 1987, 2.4% above first quarter shipments and 6.9% above last year's second quarter showing. This was only 2.5% short of the $12.4 billion shipped in the second quarter of 1984. While the growth rates in the current expansion will be more modest than in past recoveries, record-breaking dollar volume shipments will be the rule for components next year. Expect 17% growth in 1988 to $56.7 billion and 4% in 1989 to $59.1 billion.

Inventory-to-shipment ratio

Tight inventory management in conjunction with rising shipments forced the components inventory-to-shipment (I/S) ratio down last summer to 1.99, from 2.03 in April of 1987 and 2.13 in June 1986. The I/S ratio has headed down fast, with lower ratios being the rule for most electronics markets and many other manufacturing concerns. The high cost of credit in the early 1980s has taught manufacturers to keep inventory tight. By December 1987, the components I/S ratio is likely to stand at 1.92, only 11 points higher than its June 1984 ratio, its lowest ever.

ELECTRONIC ASSEMBLY

The robots that look better now

Sharp new vision systems have electronics assemblers making eyes at robots

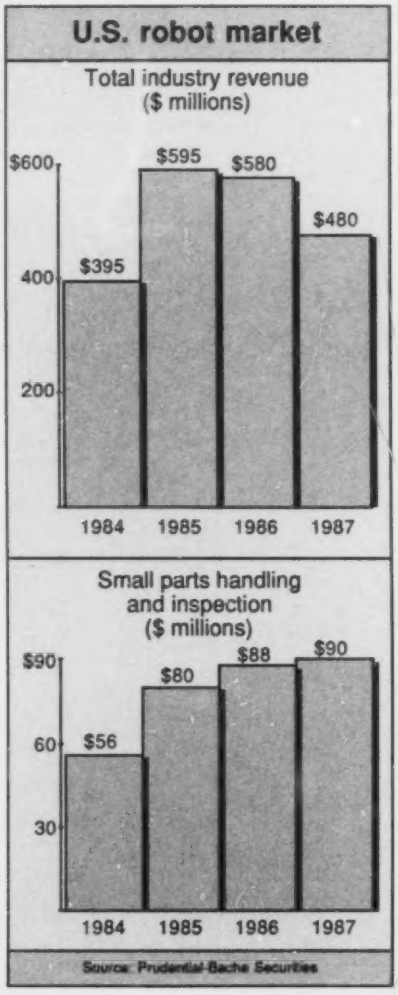
The past two years haven't been kind ones for the U.S. robotics industry. Revenue has fallen as automotive applications, such as painting and welding, have matured and become saturated. Robot industry revenue peaked in 1985 at $595 million and will fall to about $480 million during 1987, according to Laura Conigliaro, first vice president for Prudential-Bache Securities Inc. in New York City.

However, while the overall robot market has faltered, one sector — small parts material-handling and inspection — has continued to grow slowly, and will move from its 1985 level of $80 million to about $90 million this year, Conigliaro predicts. Dealing largely with electronics assembly applications, this sector has been inching forward, thanks in large part to the advent of affordable and accurate robot vision systems. High-end, standalone vision systems are also playing an important role in speeding up the inspection of components such as multilayer printed circuit boards.

Adept Technology Inc. of San Jose, a relative latecomer to the robotics market, is the clear leader in the small parts sector, and could realize revenue of approximately $35 million for 1987, Conigliaro says. Intelledex Inc. of Corvallis, Ore., is "the Avis to Adept's Hertz," says Intelledex vice president for marketing, William Mahoney. Also ranked a contender in the small parts handling market is Seiko Robotics, a division of Seiko Instruments USA Inc. in Torrance, Calif.

About 35% of Adept's robot systems are sold into electronics assembly applications, and about half of these systems are equipped with the company's vision equipment, says product manager Dave Scarborough. These percentages are almost identical to those at Intelledex, according to Mahoney. Both companies sell primarily through systems integrators, which configure the products and write programs for specific customer applications.

Vision capabilities have become increasingly important because the technology of the robots themselves is fairly static. "We look at our robot product as a core," says Mahoney, "and then look at what we can do to make it faster and more usable. Adding vision is an obvious way to achieve that enhancement."



Crude vision systems have been around for some time, but they've come into their own in recent years. Most advances have been in the software realm rather than in hardware. New algorithms efficiently perform tasks such as determining an object's presence or absence, locating circles and their centers, and finding the edges of objects. Each vendor has built up its own standard library of such algorithms and claims that this standardization has dramatically eased the job of system development.

Adept has also developed a programming environment called Assembly and Information Manager (AIM), which Scarborough says has contributed greatly to the firm's market leadership. As well as Adept's vision algorithms, AIM includes a "task level language," he says. Using this language, systems integrators can, for example, employ one command to transfer a part to a certain location; the high-level command contains all the detailed logic required to accomplish the task.

AIM also capitalizes upon the fact that the vision and robotic portions of the system are totally integrated. An AIM-developed program can freely intermix motion and picture-taking instructions, as opposed to requiring distinct programs or subroutines to direct the two components. Adept and its competitors all point to such integration as a key advancement from the days when rocket companies made robots and vision companies made vision systems. Mixing and matching such independent systems poses a daunting integration task, and can often prevent either the robot or the vision system from operating at its peak capacity.

As the robotic vision systems have grown more capable, their prices have also dropped. A system that might have cost $40,000 two or three years ago can now be had for $10,000 to $15,000. These prices, coupled with the new ease of developing vision-based systems, have coaxed a large number of once-skeptical systems integrators to take another look at vision.

Grasping properly

In typical electronics assembly applications, the vision systems assist the robot by locating a part, determining its orientation so that it can be properly grasped, and directing the subsequent placement. Adept's sys-

tems, for example, often employ two cameras, one on the robot arm, and the other inverted and stationary. The robot uses a vacuum to pull a component from a tray and then moves it over the inverted camera to determine the part's position relative to the position of the robot arm. The arm camera then sights fiducial marks on the PC board, giving the system a frame of reference to insert the component.

Robotic system cameras can perform fairly gross levels of inspection, such as surveying a part's presence, its orientation, and even the spacing between its leads. But for more complex inspection tasks, such as detecting errors in the artwork of multilayer printed circuit boards, more sophisticated vision systems are required. These systems, typically referred to as automated optical inspection (AOI) systems, can cost half a million dollars and rely upon advanced pattern recognition and artificial intelligence techniques to perform their tasks.

Two companies dominate the AOI market: Orbot Inc., based in Woburn, Mass., and Optrotech Inc. in nearby Billerica. Orbot did more than $15 million worth of business in the first six months of this year, according to president Hai Benron, who claims his firm accounts for half of the entire AOI market. Unlike the robot vision companies, the AOI companies sell their products directly to end users.

For the hefty price of the AOI systems, buyers can achieve faster and much more reliable inspections of their boards than human inspectors can provide, resulting in better yields, less scrap, and higher revenue, Benron says. The Orbot system can scan up to 32 square feet per minute at a gross level of resolution, and although speed drops as the resolution increases, the system still easily outruns human inspectors.

Given their prices and capabilities, the high-end AOI systems have little in common with the integrated robotic vision products. Still, both types of systems are proving their ability to give manufacturers a critical edge over non-automated competitors. As a result, for both the assembly and inspection stages of electronics manufacture, companies are beginning to view vision systems of all types as required components for successful operations.

DWIGHT B. DAVIS

INTEGRATED CIRCUITS

What users want from graphics chip vendors

Flexibility and speed are just two of the features that graphics equipment makers want in their ICs

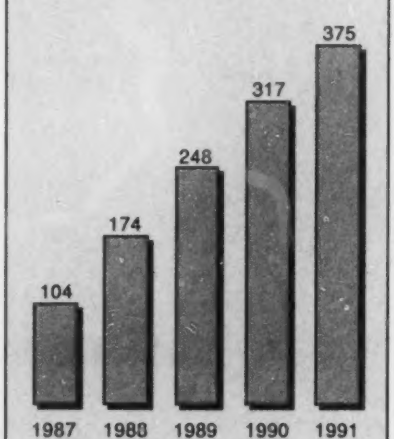
Graphics chip designers have gone back to the basics recently in an attempt to find new ways to reach somewhat jaded computer users. What they have found, according to one graphics equipment manufacturer, "is that the object of graphics companies is to replace paper and pencil functions with graphics functions. Only when we do this will we meet peoples' expectations."

Trying to meet users' needs today are a bevy of high-end and mid-level graphics solutions that offer functionality that is, in some cases, 10 times better than previous products. Even today's low-end products are considered "high end" when compared with the levels of functionality available several years ago.

At the high end, graphics equipment typically demands high resolution — at least 1,000 lines on a screen. It often calls for high speed, for three-dimensional manipulation of images, for palettes of thousands of colors and for complex shading of the displayed objects, to make them appear more realistic. Graphics chips are also required for proliferating low-end applications such as banking terminals, video games and even the electronic displays inside an automobile.

High-end PC graphics and imaging board sales

(U.S. sales, thousands of units)



Source: Dataquest Inc.

Historically, graphics were generated more by software than by hardware, were often slow, suffered from the "jaggies" (the way in which low-resolution graphics present diagonal lines as a series of steps instead of as a smooth line) and were far from the quality demanded by both business and scientific users.

Today, the mechanics have changed, as sleek new graphics chips step in to substitute for the overworked central microprocessor. Not surprisingly, the market for these highly functional chips is growing rapidly.

According to San Jose-based market research firm Dataquest Inc., U.S. vendors will ship 104,000 units of high-end intelligent graphics and imaging controllers in 1987, and that number is forecast to increase to 375,000 by 1991.

Graphics controllers are not the only graphics chips in demand. Video RAM integrated circuits are also required to store the massive amounts of data contained in, say, a 3-D image. And users are calling for application-specific graphics chips too.

Stalking graphics standards

The solutions offered today by chip designers all offer a high level of performance, but that is where the similarities end. As with many new markets, there are daily battles over standards, over single versus multi-chip solutions, and over prices.

As one graphics chip manufacturer puts it, "Each of the six major manufacturers has chosen to approach high-end graphics in a different way." As if that weren't enough of a problem, IBM recently threw the graphics

industry into disarray with its Personal System/2 graphics standards announcements, including the Video Graphics Array (VGA) standard, as well as its new, higher end 8514 standard. Now the industry, which has struggled with standards such as the Enhanced Graphics Adapter (EGA), will have to draw some battle lines.

According to Dataquest's senior industry analyst Michael Tyler, IBM's entrance into the market does not confuse matters; it validates the market. Tyler characterizes the VGA as a fairly low-end standard that will have little impact on the high-end. Meanwhile, the 8514 will crystallize high-end standards, he says, and give vendors in this market, whose equipment has traditionally not been IBM-compatible, a flag to rally around. All this can do, he says, is boost business.

Debate also rages over the virtues of single-chip versus multi-chip solutions, with "Is one chip enough?" as the nagging issue. Companies like National Semiconductor Corp. of Santa Clara, Calif., claim that the high levels of flexibility, cost control and "pick and choose" functionality, more than justify the extra board space required by multiple chip solutions. But not everyone agrees.

"The original equipment manufacturer (OEM) channel would prefer a single-chip solution, that's obvious," says Thomas Stevenson, sales and marketing vice president for Fremont, California-based graphics board maker Video Seven Inc. His company believes this so strongly that it is currently boiling down its four-chip solution into one chip, he says.

Michael Krell, graphics strategy development manager at Sunnyvale, California-based Advanced Micro Devices Inc., which has a single chip, hardwired offering, says that the type of solution is less important than its implementation. And in any case, it certainly depends on the size of the system, he explains, because the number of chips is less of an issue.

Price is another battleground, with cost cutting occurring throughout the industry, despite the fact that the hardware-based graphics market is still in its infancy. One way to keep prices up is the Intel Corp. solution, which Intel's graphics product manager, Jean-Claude Sarner, says is to offer two different chips for both low- and high-end solutions. This way, a user can remain cost competitive, and Intel can keep a share of the higher priced, high-end market.

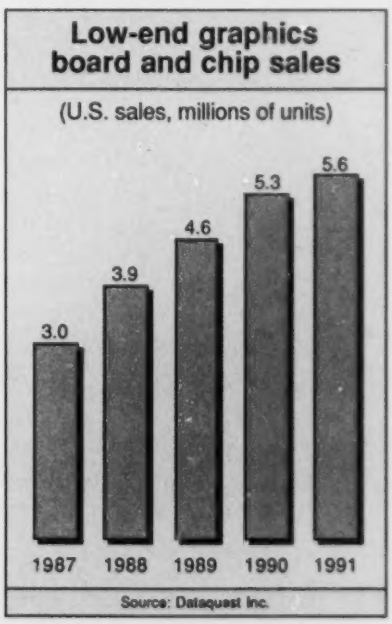
Texas Instruments Inc., headquartered in Dallas, recently reduced prices on its 34010 graphics processor by 40%; Gene Chao, president of Hillsboro, Oregon-based graphics board maker Metheus Corp., says his company is trying to push prices for high-end graphics down as close as possible to the pricing on lower-end EGA standards.

One company that is concerned with keeping prices up is Video Seven. According to marketing chief Stevenson, the board market is under intense pressure to reduce its prices. In a primarily retail market, he says, price is everything. Video Seven, however, would like to try to keep prices at a reasonable level.

More for less, please

Powering the demand for these chips are users in a number of different applications fields, all of whom are demanding more functionality at a lower price point.

For some users, flexibility is key. According to National Semiconductor's graphics marketing manager Roger Rake, his customers demand flexibility above everything else. "We try to be open for the system designer," he says. "We don't want him to feel trapped. We have many devices a designer can choose from to give him the maximum flexibility and performance in his design, and he can control the cost this way."



At Beaverton, Oregon-based instrument and graphics equipment maker Tektronix Inc., which recently introduced a graphics personal computer using TI's 34010 graphics processor, senior engineer Dave Straayer says that flexibility with his customers can count more than performance. "Graphics is an odd type of business," he says. "There are special needs and feature sets, and any product that has additional flexibility to fulfill those needs is going to be wanted. The TI part was seen as more flexible than the Hitachi or the Intel part," he says. "I was surprised that people were willing to put up with marginally less performance for more flexibility, but they were."

In addition to flexibility, users are demanding higher resolution, even for business applications, says Metheus' Chao. When Intel was designing its graphics processors, the 80276 and the 802716, flexibility and resolution were two of the most critical areas, says graphics product manager Sarner. As evidence of Intel's flexibility, users can choose exactly what functionality they require from a chip, Sarner says. For example, a user can choose between high resolution and a large number of colors.

With all this added functionality comes the question of speed. If the extra features slow down the system, it is worthless to users, says National's Rake. "A major trend in the marketplace today is higher performance graphics overall," he explains. "We hear all the time that this is a great system, but it doesn't handle graphics consistently or effectively, so the perception is that it is a slow machine. Software-based graphics are a letdown. We have to give the perception of blazing speed."

National's solution to that dilemma is to offer a number of graphics chips that can work in tandem with the main processor in order to off-load much of the work. According to Rake, this approach helps users retain their existing software and doesn't force them into choosing a new processor.

Looking forward, graphics chip designers and manufacturers see a remarkably similar future. Almost everyone agrees that, "Color is going to become far more common," as National's Rake says. "By 1988 there are going to be a large number of PCs and workstations in color."

VALERIE RICE

ATE

A little consolidation never hurt anybody

The pundits have been predicting it for years. Now it looks as if a shakeout in the ATE market is finally under way

Within one month this summer, two announcements rocked the close-knit world of automatic test equipment. In July, board test leader GenRad Inc. closed down its West Coast chip test division after absorbing years of losses. Thirty days later, Teradyne Inc. announced its intent to acquire board tester Zehntel Inc. for $75 million in stock. That move will vault Teradyne to number one in the worldwide $1.6 billion ATE market, according to San Jose market research firm Prime Data Inc.

Other potential partners are eyeing each other warily. Start-ups Semiconductor Test Solutions Inc. of Santa Clara, Calif., and Axiom Technology Corp. in Newton, Mass., share some venture capitalists, and STS president David Mees admits there might be something to gain from a match. And Steve Bisset, president of San Jose-based Megatest Corp., when asked about reputed offers from European electronics giants N.V. Philips GL and Siemens AG, hints that he might be willing to listen.

Meanwhile, with GenRad's chip-test business now gone, two-year-old whispers of a merger between GenRad and LTX Corp. are starting to circulate again. Graham Miller, president of Westwood, Massachusetts-based LTX, says that he did talk to GenRad and also looked at Zehntel a few years ago, with the idea of getting his strictly chip-testing company into the board test business. Miller evinces no interest in such activities now: "Board test is something we're not too willing to make any further investment in now."

Although GenRad says it had $27 million in sales at the high end of the component test business in 1986, competing for the crowded $325 million segment proved too expensive. The Concord, Mass., company took a $34.5 million write-off to cover the phasing out of the product line. The competition has mixed emotions.

– "It's sad in a way," says Irwin Pfister, vice president in charge of Schlumberger Ltd.'s chip test operations in San Jose. "But we've been saying it for a long time: it takes a lot of real money –- not just a percentage of revenues — to keep your performance at the edge, and only a few of us have it. It takes us over $20 million a year in R&D. That's bigger than most companies are in revenue."

Adds Frederick Bihler, president of the U.S. operations of Japanese chip tester Advantest Corp., "I'm sure it was a good decision for their company. If you can't support the effort 100%, you'd better get out of the business. The cost of developing one of those systems is horrendous."

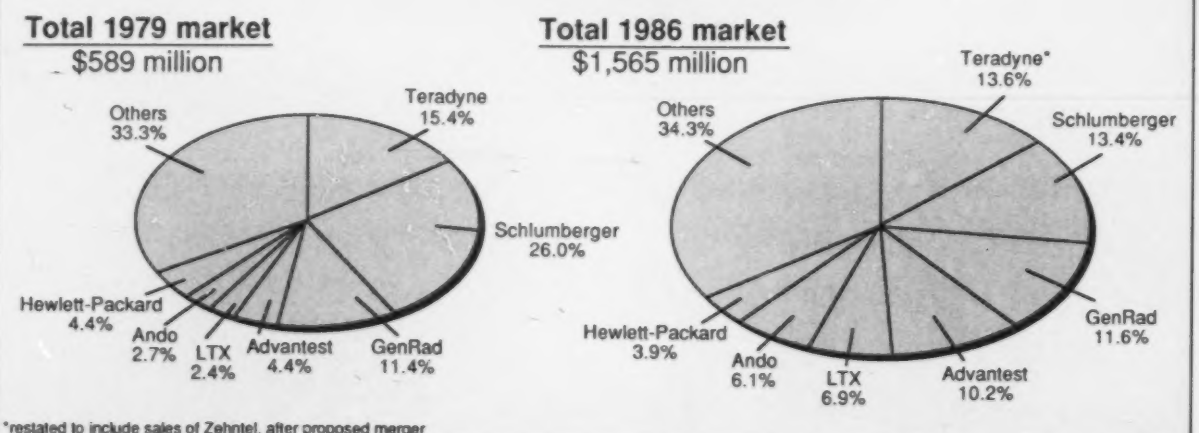
Others are extremely pragmatic. "It's great. There's a 12% market share up for grabs," says Edward Rogas, vice president of Teradyne's chip test division in Agoura Hills, Calif. "GenRad's exit doesn't make a lot of difference, but it changes the supply/demand ratio somewhat. It might affect pricing," says Megatest's Bisset. "The Delco [unit of GM Hughes Electronics Corp.] alone makes it interesting," Bisset continues. "Whoever wins it, a company like Delco represents a lot of business."

The Delco decision

Indeed, automobile-electronics giant Delco, based in Kokomo, Indiana, was one of GenRad's prime customers. Delco IC test center supervi-

ATE leaders, then and now

Worldwide sales ($ millions) and percentage of market share



*restated to include sales of Zehntel, after proposed merger

Source: Prime Data Inc.

sor John Lods claims that he isn't too upset with GenRad's exit, as his base of GenRad testers was never as big as that of his older Schlumberger line. Lods maintains that he had already started evaluating "next generation" machines. "Maybe this will speed up the process a little bit," he says, estimating that he might make a decision before the end of the year.

Does any particular ATE supplier have an inside track at Delco? "The decision now will be more clouded than it was four years ago," Lods says. "All the testers are a lot closer to being comparable now." Delco has a roomful of LTX linear testers, Lods says, but he's still a little leery of LTX's newer Trillium digital line. "I'm very, very conservative. I don't like serial numbers in the single digits," states Lods. "But Trillium has some track record on it now — even the Sentry 50 [from Schlumberger] has some track record."

Besides Delco, other plum customers left by GenRad include Advanced Micro Devices Inc. and Motorola Inc.'s microprocessor division, according to Teradyne's Rogas. The Air Force's very high-speed integrated circuit (VHSIC) contract out of Rome Air Development Center is also fair game. "There are people at the Air Force cutting their throats."

The consensus among observers is that Teradyne's proposed acquisition will allow it to make a serious run for GenRad's board tester dominance. Zehntel marketing vice president Craig Pynn says that his approximately $40 million in sales last year in the mid to low end of the board test business fit nicely with Teradyne's $70 million, mostly in the high end. GenRad marketing executive John Zapf says that the two competing companies' product lines are "complementary," but lack "synergy." He concedes that until now, "Teradyne was locked out of the low end."

Prime Data analyst Kenneth Neff's numbers show that if Teradyne's sales are restated to include those of Zehntel, there is a new leader in the overall ATE market. However, the old leader, Schlumberger ATE, cautions that not all marriages are heaven-made. "Merging cultures may be difficult. We should know," says Schlumberger's Pfister. He recalls some bumpy ground which Schlumberger traveled in acquiring the old Fairchild Camera and Instrument Corp., not to mention a deal for Accutest Corp. that was deemed by the Federal Trade Commission to conflict with anti-trust guidelines.

Irvine, Calif., board tester Computer Automation Inc. agrees that Teradyne's line is broadened, but Computer Automation president Douglas Cutsforth sees a more concrete goal in the plan. He says that Zehntel's 3200 tester has sold well to some computer companies, one Big Blue one in particular. Teradyne L200s were being replaced by Zehntel machines at IBM's Boca Raton, Fla., facility, says Cutsforth, and IBM is just the type of blue-chip customer Teradyne likes to service. Analyst Carolyn Rogers of San Francisco investment house Hambrecht & Quist Inc., says that works both ways —that Zehntel was trying to get into IBM's Austin, Texas plant, but the IBMers there thought Zehntel was too small a company to bet on.

Pynn won't comment on IBM, but does say he's had success with computer makers. "We have a good reputation but we still run into people who say, 'Zehntel's a little company — will they be there in a while to support their products?' " Pynn says. "That kind of thing will go away." Even GenRad's Zapf agrees on that. "A lot of people question a small company, but nobody questions Teradyne," he says.

So, is further industry consolidation in the cards? Some analysts have no doubt about which way ATE makers should go: "You've got to get a partner fast," says Stephen Balog of New York City brokerage firm Prudential-Bache Securities Inc. He's been forecasting a shakeout for years, which he points out is not necessarily a bad thing for the industry. "There's no shame in being the Oldsmobile division of GM," Balog says. "What you don't want to do is end up like Studebaker."

DAVID CARD

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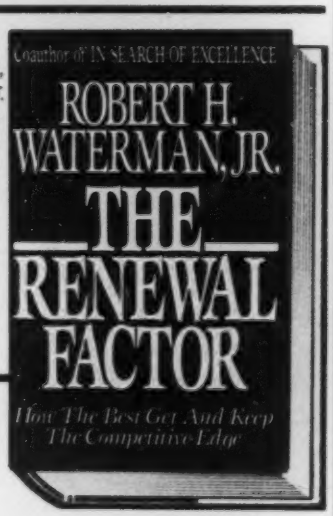
In his first book since *In Search of Excellence*, Robert H. Waterman, Jr. shows how these companies—and leaders in other industries—successfully confront the challenge of change. Read it and discover a whole new way of thinking about yourself, your company, and your future.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How The Best Get And Keep The Competitive Edge

A BANTAM HARDCOVER

DISTRIBUTED PROCESSING

DBMS and the rise of generic computers

Database management systems are moving from mainframes to workstations. Software companies may reap the rewards

By Anne Knowles

Digital Equipment Corp. has made a fortune at it. Workstation makers have entrenched themselves in the industry because of it. And personal computer makers have built a billion dollar business around it.

The idea is distributed processing. Decentralize your computer power, put a piece of it at every desktop and use industry standards to communicate with one another. Hardware makers have been touting the idea for years.

But now, software makers are getting in on the act. More than machines can be distributed. Database management systems (DBMS) — the software that manages, stores and updates computer databases — have been, until recently, in the mainframe's domain. Huge and cumbersome, DBMS wouldn't fit anywhere else. And they were so complex, no one but a mainframe programmer could deal with them.

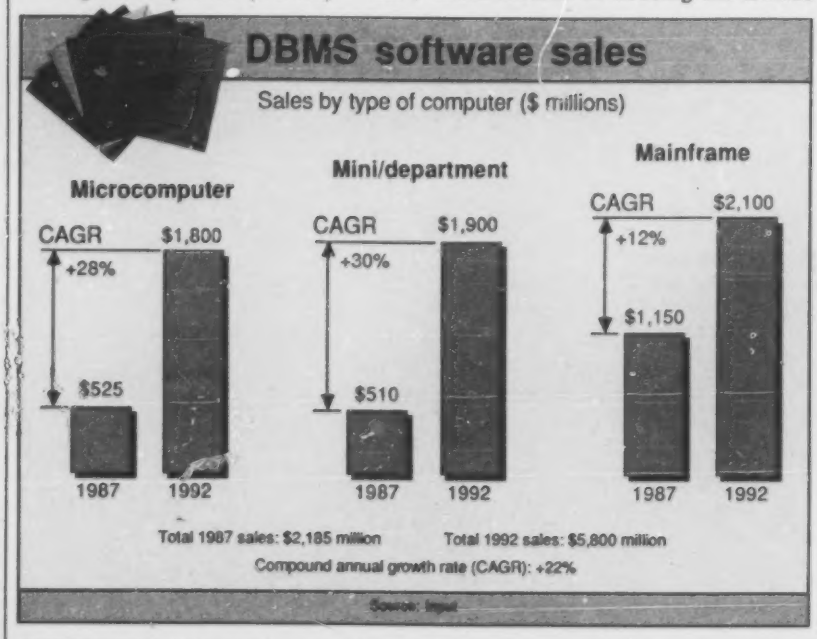
But software companies have ported DBMS to almost every hardware platform possible by centering their systems around certain standards — such as the IBM-developed Structured Query Language (SQL) and the AT&T-developed Unix operating system — and new, relational database technology.

And now they are distributing them. Instead of housing the DBMS on a central processor, software companies are splitting them up among computers of various makes and sizes in various locations. What that means for the user is faster, easier, and transparent access to information anywhere in the corporation. In manufacturing, for example, plant-floor processes can be changed, company-wide inventory can be tracked and manufacturing quality can be monitored in close to real time.

What that also means to the customer is little to no allegiance to any particular hardware platform. If databases are distributed among heterogeneous hardware platforms, and information is flowing freely between them, then, theoretically, the hardware hardly matters. And that implies the dawn of generic computing — a world in which workstations, like personal computers, are viewed as commodity products, and in which price is more important than the logo on the computer housing.

Comments Michael Cohn, an analyst with market research firm Input, in Mountain View, Calif., in his report on DBMS markets: "Based on performance improvements and the potential of the distributed/relational DBMS architecture, it is believed that off-the-shelf hardware will have no difficulty matching or surpassing the performance of proprietary hardware-based DBMS products."

Hardware makers may be concerned. While computer manufacturers may sell proprietary DBMS, it is of little value to them to promote open communication with different vendor's systems. And many observers say that the software tools — such as fourth generation languages



Just like generic goods in a supermarket, widespread use of DBMS software coupled with distributed processing, could lead to generic computers

(4GLs), natural language interfaces and optimizers which enable users to access data in the most efficient way — are what will differentiate one database product from the next.

User demand

Nevertheless, demand for workable DBMS products is running high among the original equipment manufacturing community.

"Communications issues such as MAP [Manufacturing Automation Protocol, a networking protocol proposed by General Motors] have gotten a lot of attention," says Peter Martin, manager of system product planning at process control supplier Foxboro Co. "But open information is just as critical an issue." Especially on the factory floor.

So last April, Foxboro announced its Intelligent Automation Series, a group of products aimed at the computer-integrated manufacturing market. Included in the bundle are ruggedized processors based on Intel Corp.'s 80x86 chips, instruments and a database management system.

Foxboro is providing the processors and Informix Software Inc. is supplying the DBMS. Foxboro will also add software tools. "The system will collect data across the whole plant in real time," says Martin. By the end of summer, the company claimed it had $40 million in back orders. Shipments began in October.

Foxboro chose Informix because the software company's DBMS was already well-positioned in the market, Martin says. By year-end, Informix would also have distributed DBMS capabilities. And Foxboro's customers, says Martin, wanted standards, primarily in the area of languages, which would enable them to integrate their data in a consistent way.

And other hardware manufacturers are OEMing DBMS products, based on similar criteria.

Consequently, Relational Technology Inc., an Alameda, California-based DBMS supplier, claims to have an optimizer for its Ingres software product line that can improve performance a thousand times. "It is the difference between whether a certain application is feasible or infeasible," says Bob Williams, director of product line marketing at RTI. Tools, especially those based on artificial intelligence techniques, are one more step

Gerry Baskin

away from proprietary hardware.

But technical issues – such as performance, networking and data integrity — do remain. Even companies that offer so-called distributed DBMS say they are incomplete. And human issues are surfacing. As with all new technology, it takes time for users to acquire a taste for it. "The implementation process hasn't been a fast one," says Peter Tierney, vice president at Oracle Corp., a Belmont, Calif., supplier of relational and distributed databases. "The technology is there, people want some more functions, but the fact is people don't know how to use it." Concludes Tierney: "I wouldn't want to be with a company betting their future on distributed databases."

At least not their immediate future. But within five years, estimates Input, distributed DBMS will account for about 15% of the $5.8 billion market for database management systems. Others guess higher. All observers, though, agree that by 1992 relational DBMS, which distributed DBMS are based on, will represent at least 50% of the total market. Says Richard Finkelstein, vice president with Codd and Date Consulting Group in Chicago: "Everything else [nonrelational] is dead."

"Databases, until today," says Finkelstein, "were analogous to black holes. They sucked in vast amounts of data that you couldn't do anything with." Until relational technology was developed, by E.F. Codd (of Codd and Date Consulting Group) at IBM's San Jose facility in the 1970s, all DBMS were hierarchial. Data was structured in a hierarchial order and to question it, users needed complex commands.

Relational DBMS place data in tables and establish some logical relation between pieces of data contained within those tables. And relational databases can be accessed through query languages, such as SQL, that require only a few simple commands.

Language barriers

Other query languages have been developed. QUEL, written at University of California at Berkeley at the same time Codd was working at IBM, was initially used by RTI, which was founded by the UC Berkeley researchers. But SQL has established itself, first as a de facto industry standard, due to IBM's backing, and then as an American National Standards Institute standard.

Ironically, though, IBM was not the first to implement SQL or relational technology. RTI was the first to offer a relational DBMS and Oracle, in 1979, was the first to bring out a system based on SQL. IBM, on the other hand, waited untill 1983 to announce DB2, its relational SQL DBMS for its mainframe systems.

IBM also has not incorporated distributed functions into its DBMS offering though the company is reportedly ready with a commercial product which evolved from its distributed DBMS research effort, called R*Project, in San Jose.

While SQL makes it easier for users, it is a barrier to suppliers. It is not an easy standard to follow. Codd and Date's Finkelstein estimates that there are only a dozen people capable of writing SQL engines for DBMS. Otherwise, says Finkelstein, it takes three years to develop. So, companies are acquiring it, one way or another.

SQL, though, is not prerequisite for participation in the PC DBMS market, says Randy Sutherland, an analyst with Dataquest Inc. SQL is vital for networked databases. But many PC database systems, says Sutherland, are used as standalone systems. They are limited by the amount of memory within a PC operating system but fully relational DBMS, such as Ashton-Tate's dBase products, run on microcomputers.

That is fortunate for PC DBMS vendors that now have IBM to compete with. IBM's extended version of OS/2, the new operating system for its PS/2 line of microcomputers, will have a SQL-based DBMS embedded within the operating system. That may lock up the *Fortune* 500 market for IBM, says Sutherland.

But opportunities for third party vendors, says Sutherland, still exist in the standalone PC market. And

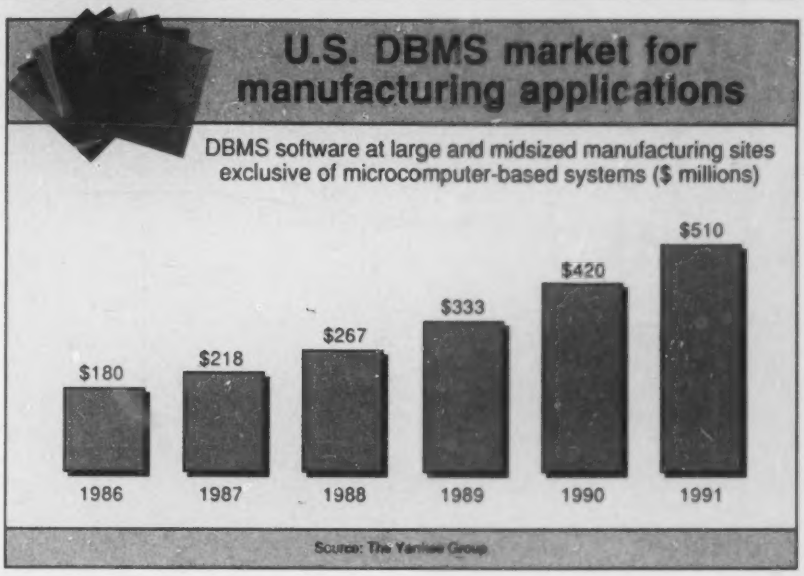
SYBASE PRESIDENT HOFFMAN catches Apple's eye, and investment, with Sybase's distributed DBMS.

Liane Enkelis

also within the still-vital market for MS/DOS — the standard operating system currently running on IBM PCs and compatibles. In fact, Microsoft Corp., developer of both MS/DOS and OS/2, is expected to enter the PC DBMS market within the year, as is Lotus Development Corp., developer of the Lotus 1-2-3 spreadsheet application package. And the DBMS market for non-networked PCs running the first version of OS/2, sans an embedded DBMS, will be left up for grabs. Says Sutherland: "The third party vendors will have to duke it out for the rest."

IBM isn't the only PC maker with databases on its mind. Apple Computer Inc. recently made an estimated $1 million investment in Sybase Inc., a Berkeley, Calif., supplier of distributed relational DBMS for Sun Microsystems Inc.'s Unix-like operating system and DEC's VMS. Sybase is expected to provide Apple with a DBMS for the micro makers as yet unannounced version of Unix. Says Mark Hoffman, Sybase president: "Unix is the most logical way to go."

Sybase has plans to announce compatibility with IBM's DB2 mainframe DBMS, allowing any Sybase-developed DBMS for Apple to be linked to a corporate mainframe running DB2. Currently, Apple's Hypercard product, which was announced at the MacWorld trade show this summer, contains a DBMS. Dataquest's Sutherland says it is not a full-blown relational database system but it is a "powerful database considered part of the operating system." If all the pieces fall into place for Apple soon, says Sutherland, "it is conceivable Mac users will have exactly what IBM users have only been promised."



But IBM has, at the least, made its intentions clear. DB2 successfully staved off the success of third party vendors in the mainframe DBMS market. Mainframe DBMS vendor Cullinet Software Inc., for example, has been losing money for the past year and a half and has since plunged itself into the midrange computer software market. IBM's dominance in the mainframe DBMS market is ir-

The need for new guidelines

After E.F. Codd developed relational database management systems at IBM in the 1970s, and companies started announcing relational products, the marketplace was engulfed in confusion. Some vendors provided certain functions, and others did not. So, Codd developed a list of the 12 principles behind relational technology.

Today, all relational DBMS are judged by it.

Soon, Codd — now of Codd and Date Consulting Group in San Jose — is expected to release a similar list for distributed database technology. None too soon. Now that independent software vendors and hardware manufacturers alike are marketing so-called distributed DBMS, chaos has hit again.

No such set of guidelines exist today. But most experts agree upon certain minimal functions that a relational DBMS must have in order to distribute it.

First, is referential integrity. Richard Finkelstein, a vice president with Codd and Date, says it is one of the principles of relational technology that no vendor, to date, has incorporated into a DBMS. It involves how data is arranged within a database. Data in a relational DBMS is laid out in tables with cells similar in appearance to spreadsheets. For each table there is a primary key, a domain, and a foreign key. The combination of those three components allow tables to be cross-referenced.

Another issue is how the database is distributed. Are entire versions of the database replicated on each system in the network? Are they partitioned into mutually exclusive subsets, with no replication? Or is it a hybrid solution, where data that is vital to one location, but not to another, is partitioned to that processor, and common data, shared by all nodes on the system, is replicated at each processor?

Updates are another problem. Data must be accurate at all sites. If information is changed, or added or extracted, on one node, all the other nodes must reflect that. Two-phase commit, offered only by Sybase Inc. to date, also has to occur. If, for example, a bank customer transfers money from one account into another — debiting and crediting within the same transaction — the DBMS must be sure that both phases of the transaction have been completed.

Some say performance is an issue. Relational technology pays a penalty in performance in exchange for ease-of-use. Distributed DBMS rely on other technologies — such as networking — that are still advancing. And the further that artificial intelligence techniques progress, the more willing the user will be to distribute a database. □

refutable; last year, IBM's DB2 and IMS DBMS accounted for about 40% of the IBM-compatible mainframe database systems market.

"IBM knows that whoever owns the corporate database," says Codd and Date's Finkelstein, "owns the corporation."

Midrange melee

That may depend upon how one envisions the corporation — as a plethora of PCs networked to a centralized mainframe or as a network of workstations, PCs and departmental systems.

In the relational and distributed DBMS market, most of the action has centered around the midrange. Much of the innovation has occurred there; Oracle, RTI, Tandem Computers Inc. and Sybase are the handful of companies offering distributed DBMS today. Other midrange players, such as Menlo Park, California-based Informix Software Inc. and Lake Oswego, Oregon-based Unify Corp., plan to announce distributed DBMS by year-end.

Their collective genesis was in the midrange. For RTI, it was in the DEC VMS market. Oracle started by porting its DBMS to Unix. All of these companies have also migrated downward, into the PC arena, by porting their systems to MS/DOS. And they offer DB2 compatibility. "If someone has DB2 and is committed to it," says RTI's president, Paul Newton, "we don't tell them to throw it out." Concludes Newton: "We'll never blast IBM out of the DB2 environment."

RTI'S PRESIDENT NEWTON: "DEC has expanded into corporate America over the last few years. We'll ride on their coattails."

Mainframe DBMS vendors can understand that. The midrange software companies with their minicomputer-oriented offerings are growing while some mainframe third party DBMS vendors have stagnated. Oracle, which has been public for over a year, increased its sales 136% last year, to $131 million, while its net income rose 170%, to $15.9 million. Informix's revenue has doubled each year for the past four years. RTI added 700 customers to its list last year and is recording 80% sales growth annually, according to company president Newton. But that would put the privately held company somewhere in the $50 million revenue range, up 80% from its own reported $28.1 million in sales in 1986. That is less than half of Oracle's sales.

The rivalry between the two companies is well known. Peter Tierney was vice president for marketing at RTI until this past January when he

A view from the top of the Pyramid

It's clear today that DBMS is one software issue that hardware makers can't ignore.

"It isn't the hardware that is so important anymore," says Richard Rebh, director of applications marketing at superminicomputer maker Pyramid Technology Corp. "It is the integrated hardware and software."

"Database software is as critical as systems software is to us now," says Rebh. While DBMS vendors have been busy porting their systems to many hardware architectures, Pyramid has been busy signing deals with DBMS suppliers. There are now between 16 and 18 databases available on the supermini makers' hardware, says Rebh. And now the company is forging into the on-line transaction processing market with a new line of processors, based on the company's Series 9000 superminis and Sybase Inc.'s distributed relational DBMS. The new systems are called R*tp.

"Sybase in the only product that will take Pyramid into on-line transaction processing," says Rebh. "Sybase has leading edge product. And there are no performance penalties."

Sybase is now part of an ambitious plan, on Pyramid's part, to provide DBMS for its hardware. The push to provide databases started in February, when Pyramid launched an official DBMS program. The program is divided into three categories. Prism products is a customer catalog of third party DBMS available for Pyramid. Pyramid Partners is a value-added reseller program in which Pyramid resells and supports third party DBMS products. Pyramid Products is a classic original equipment manufacturer relationship between the hardware company and software vendors in which Pyramid sells DBMS under the Pyramid label.

Informix, Oracle, RTI and Sybase have all been signed up since February. Sybase's distributed relational DBMS is a Pyramid Product. And Informix, Oracle and RTI are all Pyramid Partners. Says Rebh: "We're supporting RTI for technical users, Oracle for commercial users, and Informix for smaller applications." □

Liane Enkelis

joined Oracle. RTI claims to have had the first commercial distributed DBMS system on the market, with installations in two dozen major corporations. Oracle's Tierney claims RTI's Ingres/Star is only installed as production units. "Just ask RTI," says Tierney. RTI's Newton counters that other distributed DBMS on the market "are just toys." The debate goes on.

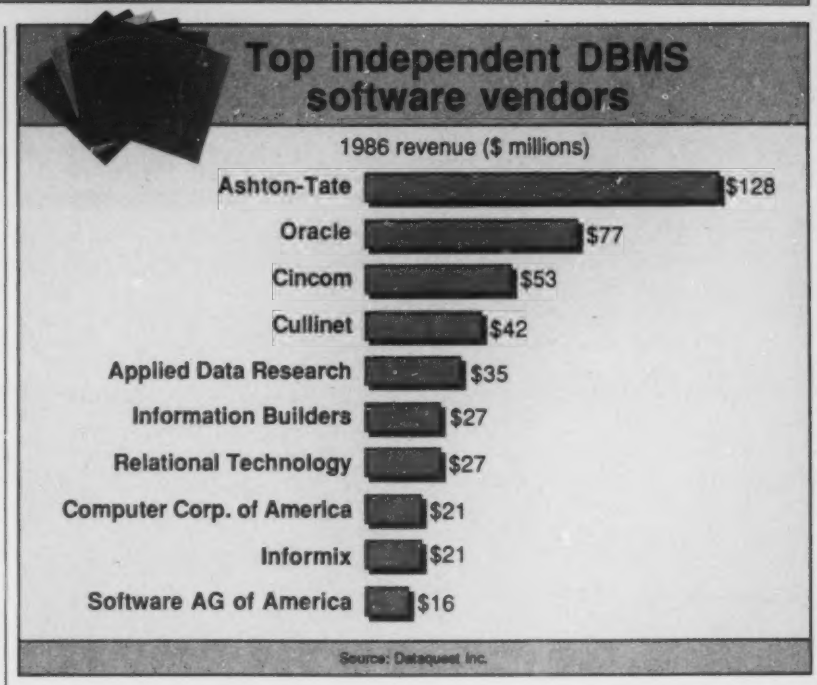
RTI became famous in the industry as a scientific and engineering DBMS vendor because of its origins in academia and its early adoption of DEC's VMS operating system. Since then, though, the company has adapted its Ingres DBMS to IBM's VM operating system, MS/DOS and about 25 different hardware platforms running some flavor of Unix. And now it is poised to follow DEC into the *Fortune* 1,000. "DEC has expanded into corporate America over the last few years," says RTI's Newton. "We will follow on their coattails."

Oracle, on the other hand, has always been recognized as a commercial DBMS vendor. Among its OEM customers Oracle claims AT&T, Prime Computer Inc., Wang Laboratories Inc. and Xerox Corp. And, of course, IBM. Big Blue has marketing rights to Oracle for its RT PC, engineering workstation, and its System/88 fault-tolerant system which it buys from Stratus Computer Inc.

RTI has a much-coveted deal with DEC. DEC resells Ingres for its Unix-like Ultrix operating system. Informix can claim Tandem Computers Inc., a hardware maker in the on-line transaction processing market that relies on DBMS for its bread and butter. Tandem resells Informix's Unix-based DBMS for its customers using LXN, Tandem's Unix-like operating system.

But the companies' customer lists also intersect and overlap. All three companies can claim AT&T, IBM and General Motors Corp. among their buyers.

For a relatively late entrant, Sybase is already "a well-connected company," says Input's Cohn. In addition to its investment from Apple, the Berkeley-based start-up has an OEM arrangement with Pyramid Technology Corp., and reportedly with Stratus. Sybase started shipping product last April. The deal with Stratus, says Hoffman, is for "exploration of joint technology." So far, the company has ported its system to DEC's VMS and Sun's Unix.



Sybase is taking a different approach than most midrange DBMS vendors. While Informix, Oracle and RTI have ported their DBMS to literally hundreds of hardware platforms, Sybase's Hoffman says Sybase plans to limit itself to only a handful. In addition to VMS and Sun's Unix, Hoffman says, Apple's Unix, IBM's VM operating system for its 9370 midrange computer, MS/DOS and OS/2, are among the other strategic platforms Sybase plans to utilize.

Most advanced DBMS

Sybase also has, by many accounts, the most advanced distributed DBMS offering. The company has incorporated what is called "two-phase commit," within its relational DBMS. Two-phase commit — a necessary function for a truly distributed DBMS — guarantees that two, or more, interdependent transactions will not occur individually unless both occur. A banking transaction, for example, may involve debiting one account in order to credit another account. Two-phase commit ensures that either both the withdrawal and deposit happen, or nothing happens at all.

That puts Sybase square in the market for on-line transaction processing. Hoffman says that is the market Sybase is zeroing in on, albeit a huge one; OLTP is expected to become a $35 billion market by 1990, estimates Dataquest. The deal with Stratus — a maker of fault tolerant computers — in particular, pegs Sybase for the OLTP market.

It also pits the company, indirectly, against Tandem Computers. Tandem, both a hardware and software supplier, values its DBMS business as much as most computer vendors cherish their systems software sales. It was one of the first companies to offer a distributed DBMS, according to Frank Cluggage, Tandem's SQL product manager. In the mid-1970s, Tandem started selling its Encompass line of DBMS software and tools. And this past year it introduced NonStop SQL, a SQL-based relational DBMS for its series of NonStop processors. But Tandem's is a proprietary DBMS system, sold for Tandem systems alone.

For other hardware vendors, says Input's Cohn, that is the dilemma. DEC, IBM and others have to live in a multivendor environment. But they want to offer one solution. Third party DBMS vendors, on the other hand, exist because of the multivendor, multisolution environment. And companies like Informix, Oracle and RTI depend upon computer manufacturers for sales; generally 50% of their revenue is generated by OEM, value-added reseller and joint marketing agreements. Says Cohn: "They have to make strategic alliances with hardware manufacturers. But they can't get too close to any one vendor." □

Signs of a recovery

The computer, peripherals and related equipment market is showing signs of recovery. New orders were up 2.7% in July from the same month a year ago to stand at $4.0 billion. Aggregating the first seven months of the year, bookings were running 5.8% above the comparable period for last year. Shipments were showing encouraging signs too, with July shipments increasing 3.9% compared to July 1986. Although total shipments through the midsummer months were trailing the period for last year by seven-tenths of a percent, a brisk second half is expected. Backlogs, at $19.2 billion on a seasonally-adjusted basis, were at their highest level since the end of 1985.

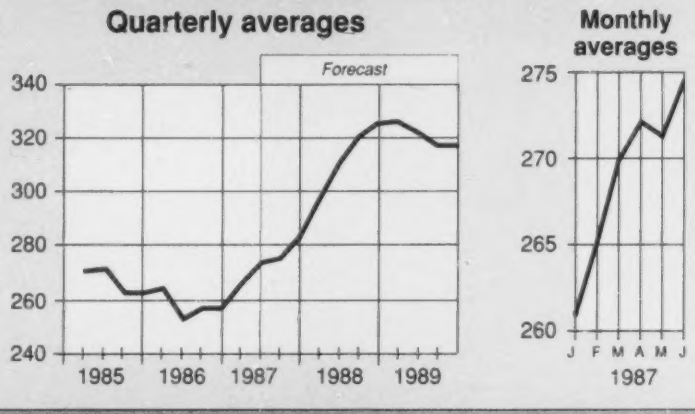
Computer manufacturers were keeping a watchful eye on inventory levels. Value of inventory in July was 8.5% below its year-ago figure. With the tight control on inventory and the slow increase in shipments, the inventory-to-shipments ratio stood at only 1.96, well below the 2.90 average in 1981.

Total employment jumped 0.8% in June to 457 million, a gain of 3.5 million jobs. This gain was reassuring since in May computer employment was at its lowest level since April of 1981. With a computer recovery now underway, employment growth should continue through next year.

More information can be obtained from Madeline Franchi, senior economist, Cahners Economics Department, 275 Washington St., Newton, Mass. 02158 Phone: (617) 964-3030.

Industrial production of computers

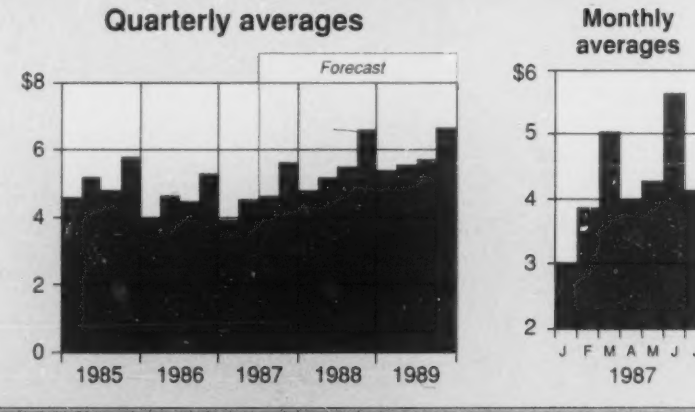
Seasonally adjusted index (1977=100)



Source: Federal Reserve Board; Forecast: Cahners Economics

Shipments of computers

($ billions)



Source: U.S. Bureau of the Census; Forecast: Cahners Economics

Computer market database

	Latest month	Previous month	Change	Year ago	Change	Next year	Change
Industrial production (SA, 1977=100, June)	274.6	271.0	+1.3%	250.7	+9.5%	309.0	+12.5%
Shipments ($ millions, July)	$4,143	$5,640	-26.5%	$3,987	+3.9%	$5,284	+27.5%
Orders ($ millions, July)	$4,009	$5,746	-30.2%	$3,905	+2.7%	$6,396	+59.5%
Unfilled orders ($ millions, July)	$19,512	$19,646	-0.7%	$19,528	-0.1%	$21,661	+11.0%
Inventory-to-shipments ratio (SA, July)	1.96	2.10	—	2.20	—	2.07	—
All employees (millions, June)	457.2	453.7	+0.8%	479.3	-4.6%	491.3	+7.5%
Production workers (millions, June)	149.2	147.6	+1.1%	162.3	-8.1%	163.4	+9.5%
Exports ($ millions, June)	$1,574	$1,386	+13.6%	$1,224	+28.6%	$1,573	0.0%
Imports ($ millions, June)	$1,587	$1,519	+4.4%	$1,260	+26.0%	$1,694	+6.7%

SA = seasonally adjusted, all other data is not seasonally adjusted

Data sources: Federal Reserve Board, U.S. Bureau of the Census and U.S. Bureau of Labor Statistics
All data for SIC 357, except industrial production, SIC 357-9. Forecasts: Cahners Economics

PASSIVE COMPONENTS

The capacitor makers who are anything but passive

The downturn taught capacitor makers a trick or two. These days, specialized products are the name of their game

By Michael R. Leibowitz

If you want lessons on what to do when your commodity market collapses, turn to the capacitor business. Executives in the $2.2 billion domestic capacitor industry can tell you how to buy out your company from its disillusioned conglomerate parents; give you tips on selling and buying ailing product lines; and pass on other strategies for staying in a business where prospects for high growth have long since faded. In the midst of industry-wide consolidation, U.S. capacitor makers have become experts on these painful topics.

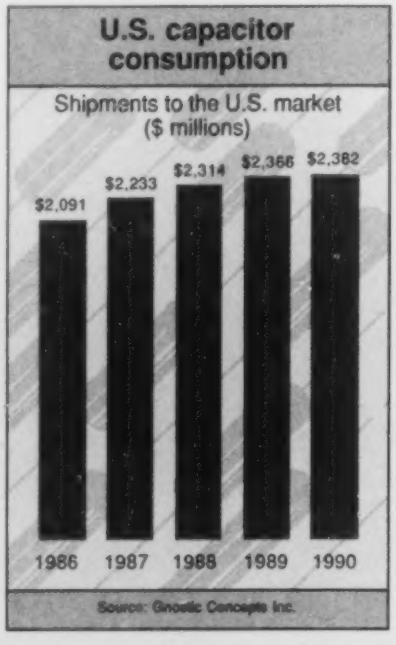
Like other component suppliers, capacitor makers found themselves severely buffeted by the mid-1980s downturn in the electronics industry. A major restructuring occurred as parent companies, unwilling to pour in the capital needed, shed some or all of their capacitor operations. Penn Central Corp. spun out the No. 1 U.S. capacitor maker, Sprague Electric Co., as a public company earlier this year. Management purchased Cornell-Dublier Electronics Inc. from parent Exxon Corp. at the beginning of the downturn. Mallory Capacitor, a division of Emhart Industries Inc., sold its aluminum electrolytic line to RTE Corp.

The upheaval is not over yet. "I think there's some further shakeout in this industry," says Steven Murray, president of Mallory Capacitor of Indianapolis, Ind. "I still believe there's too much capacity."

But while the capacitor shakeout may be far from complete, the bulk of the restructuring activities at some of the larger capacitor makers has already occurred. The industry is also enjoying some modest, but long awaited, growth. Gnostic Concepts Inc., a San Mateo, Calif., market research firm, estimates that 1987 sales of around $2.2 billion were up 7% over last year, and that 1988 industry sales will show 4% growth over this year. With some semblance of stability returning to the capacitor industry, the major players are busy implementing their strategies for survival in their chosen market segments.

Product pruning

By far, the most significant strategy for survival by capacitor makers has been a selective pruning of certain product lines and a build up of others. Manufacturers have been forced to make a hard assessment of which markets they can remain strong in and which are likely to be losing propositions.



Mallory Capacitor, in selling its electrolytic-capacitor line and placing its solid tantalum line on the block, had cut its workforce in half. "These lines were losing money and just didn't fit the strategic objectives of this company," says Mallory president Murray.

Today, Mallory has aligned itself with two capacitor businesses: DC film capacitors and wet tantalum capacitors. Mallory believes it can hold a favored position in both lines. "Our technology is good, our patent position is good, and the product lines have been profitable in the past," says Murray. "We're going to spend money on [these lines]. We intend to be the leader in those product lines that we're going to stay in."

Despite the narrowing of its product range, Mallory intends to continue to offer a broad range of capacitors to its distributors. Mallory will purchase the capacitors it does not manufacture from other makers for resale through its distribution network.

Cornell-Dublier means to stay in the aluminum electrolytic capacitor business. The firm, headquartered in Wayne, N.J., bought an aluminum electrolytic line — as well as a mica capacitor line — from Schlumberger Ltd.'s Sangamo Weston division last May. "No, the markets are not in that rapid a growth situation," acknowledges Edwin Read, senior vice president for Cornell-Dublier. "The at-

tractiveness was that Cornell-Dublier is also in those two product lines. We saw the opportunity to consolidate and expand our total manufacturing capability in electrolytic and mica."

The acquisition of Sangamo Weston's mica line, for example, will help Cornell-Dublier compete against capacitor makers from Japan and India that Read claims have been making inroads into the domestic market. "The acquisition was part of our strategy to increase market share," says Read. The same tactics apply to the company's aluminum electrolytic business.

As more electronic equipment manufacturers shift to surface mounting of electronic components, surface-mounted capacitor "chips" have become a fast-growing product area. AVX Corp. of Great Neck, N.Y., got into the tantalum chip business through the acquisition of STC Ltd.'s tantalum capacitor operation in 1986. "We bought that because we see a surge in the surface mount area in tantalum," says Marshall D. Butler, AVX's chairman. "We feel that STC had the best-designed tantalum chip."

Not all capacitor makers are using acquisitions to diversify. Kemet Electronics Corp. of Greenville, S.C., also has broadened its surface-mount product lines, but has chosen to build, rather than buy. Kemet, which president David Maguire claims maintained profitability throughout the downturn, invested $25 million in 1985 to build a world-class surface-mount ceramic chip capacitor plant. "We've been chip limited ever since we've been in the business," says Maguire. "Now we can participate in all of the [ceramic] market."

Kemet also plans to expand its product offerings into the market for molded tantalum chips; the company began tooling up to produce these parts in 1986. However, president Maguire concedes that his firm "has a long ways to go."

ASIC-type capacitors

Capacitor makers are also beginning to follow the niche or application-specific strategy recently popularized by the semiconductor industry. By focusing on smaller-volume, specialized capacitor types, vendors believe they can distance themselves from some of the vagaries of the commodity market.

"We have a host of new, application-specific products coming forth," says AVX's Butler. One example is a multilayer ceramic (MLC) capacitor that replaces larger electrolytic capacitors used in power supplies. "We can lower the weight of power supplies by 25% to 35% by using an MLC instead of a regular electrolytic," adds Butler.

Another application-specific product from AVX is an array of capacitors on a single ceramic substrate, designed to fit on the pins of a cylindrical or D-subminiature connector. This array is sold to connector manufacturers and converts the connector into a filter.

AVX sees its emphasis on application-specific products as the way to continue outpacing the market as a whole. According to Butler, application-specific products will bring AVX 25% of its sales five years from now. Today, these products represent only 10% of the company's revenue.

Reducing manufacturing costs while maintaining high quality is an immediate priority

Sprague, headquartered in Lexington, Mass., is another manufacturer targeting the specialty capacitor market. "We will start to see a dramatic change in passive components, which have been somewhat lagging relative to the semiconductor industry," remarks Peter Loconto, Sprague's senior vice president for sales and marketing.

Sprague has built a new plant to produce ceramic multilithic capacitors, which are parts that contain many isolated capacitors on a single substrate. The product can accommodate 100 or more isolated capacitors on a single substrate, depending on their size. "We feel that it's the next generation in packaging concepts," says Loconto.

For Cornell-Dublier, application-specific products are "basically the thrust of our new product development, rather than looking for large-volume markets which we probably don't do as well in as some of our offshore competitors," says Cornell-Dublier's Read. Cornell-Dublier's first application-specific products — thin-film capacitors optimized for use in electromagnetic interference filters — will be introduced within the next six months. "Within five years we'd like to have at least half our business in application-specific products," says Read.

Cutting production costs

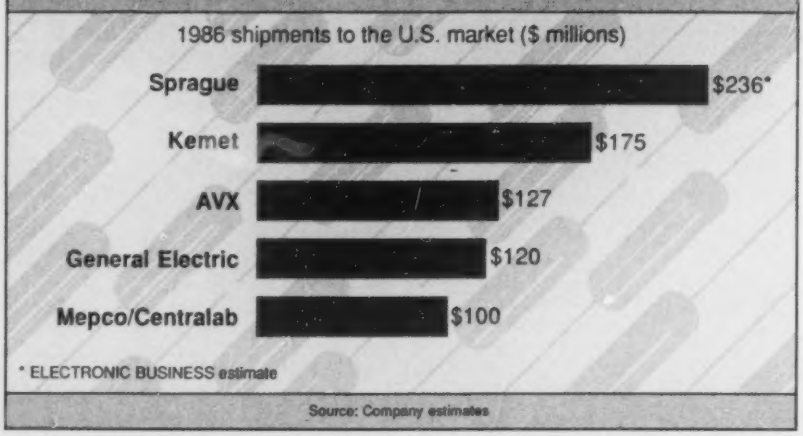
But for all capacitor makers, reducing manufacturing costs while maintaining high quality is an immediate priority. Competition in the industry remains stiff, and major capacitor customers continue to pare down their vendor lists.

Corning Components Inc., a Biddeford, Maine, division of Corning Glass, has lowered the cost of its ceramic capacitors by 15% by developing a method for producing them without using palladium, a precious metal which sells for $130 an ounce. Almost all of his competitors' parts still use either palladium or a palladium-silver alloy, claims Robert Yard, Corning's marketing manager.

In making AC film capacitors, Cornell-Dublier has eliminated its dependence on outside suppliers of metallized films, which have fallen into short supply worldwide, according to Cornell-Dublier's Read. The company produces its own metallized paper electrode in its fully-integrated capacitor plant in New Bedford, Mass.

Since becoming a private company three years ago, Cornell-Dublier has invested between 20% and 25% more

The top five U.S. capacitor makers



in capital equipment to streamline manufacturing. It has also acted to reduce costs by moving the high volume portion of its film capacitor manufacturing from the United States to its plant in Taiwan. "We're positioning ourselves to be able to [offer] more competitive pricing," says Read.

AVX is busy increasing its production capacity in surface-mounted MLC capacitors. According to chairman Butler, Japanese capacitor makers have gotten a head start in manufacturing surface-mounted components as suppliers of capacitor chips to high-volume consumer electronics markets. Now the big challenge for U.S. capacitor makers is to increase chip capacitor production and reduce costs, says Butler.

Butler boasts that AVX has made huge strides in improving the way it handles chip capacitors. "Now it's just a matter of increasing our volume — increasing our ability to test and making the yields as high in surface mount as they are in leaded devices," he explains.

In addition to investing to keep foreign competition at bay, AVX has discovered a way to grab a share of the lucrative Japanese market. Its joint venture with ROHM Corp. of Japan gives AVX 25% of a Japanese MLC capacitor company that has become the fourth-largest MLC vendor in Japan, according to AVX's Butler. Citing a broadening of his company's geographic base as a key strategy for growth, he boasts: "We're starting to do a good job in the Far East." □

Mepco/Centralab plans to outpace others

To hear the company's president talk about it, one would think the Mepco/Centralab Inc. was in the proverbial eye of the hurricane. The hurricane, of course, being the stormy state of the capacitor industry where mergers, divestitures and management buy-outs have been occurring with frightening frequency.

According to president Steven Karlik Jr., those tumultuous times are ancient history for Mepco/Centralab, a North American Philips Corp. subsidiary located in Riviera Beach, Fla. Nearly two years ago, N.A. Philips merged its Mepco and Centralab passive component operations into one corporation. (Mepco itself was a conglomerate of several companies.) Consequently, today the company is much more stable than most of its competitors, asserts Karlik. The Philips offshoot is also running leaner, thanks to the slashing of duplicate overhead. The salesforce, for one thing, has been consolidated into one cohesive national network.

Also, the company closed its operations in Milwaukee; Morristown, N.J.; and Mexico. "In the consolidation, we ended up with about one-half the corporate staff we had, so certainly there was a cost saving," says Karlik. He asserts that the restructuring is now more than 95% complete, and that his company is done with divesting. If anything, he adds, Mepco/Centralab is in the acquisition mode. Indeed, N.A. Philips announced last June that it was folding its Ohmite resistor subsidiary into Mepco/Centralab. "Now," says Karlik, "all of the passive component operations inside of N.A. Philips come under the Mepco/Centralab corporation." In addition, Karlik does not rule out the possibility of buying an outside company.

MEPCO/CENTRALAB's KARLIK: "We're probably the biggest investor in the passive component area today"

Drastic cost slashing

Even though Mepco/Centralab underwent drastic cost slashing last year, the company did not become investment stingy, asserts Karlik. He claims that the firm will spend more than $20 million this year on R&D and capital equipment; more than 75% of the money is being spent on surface mount technology. "We're probably the biggest investor in the passive component area today," asserts Karlik. "With many of our competitors' businesses up for sale, we've had a chance to look at them in order to be able to bid on them; we've seen the capital investments they've been making . . . and it's nowhere near the dollars we're talking about."

Indeed, Dutch parent N.V. Philips seems committed to the passive component business. Or at least to N.A. Philips. This fall, N.V. Philips was trying to buy back the outstanding shares of its U.S. subsidiary, in which it held a 58% interest. Robert L. Renck Jr., managing partner of New York City investment analysts Renck Levy & Company Inc., says the move was wise. He notes that previously, "Philips was fighting with one hand tied behind its back."

Having such a protective parent helps Mepco/Centralab compete vis-à-vis the company's competitors, many of which have been abandoned by their respective parent corporations, claims Karlik. "The profits weren't there for them," he says, "and they didn't want to make the investments that were needed to upgrade the quality of their technology."

Consequently, Karlik asserts that Mepco/Centralab will outpace the market this year. In fact, he is counting on a 1987 sales growth in excess of 20%. "People who see our factories and see the investments we're making realize that we wouldn't be making them if we weren't here for the long pull . . .. Philips is in the component business to stay."

But whether all this will translate into a stronger market position for Mepco/Centralab is uncertain. "Centralab is by no means a leader in this business," claims Robert Gutenstein, director of research for Kalb, Voorhis & Co. of New York City. "They've put a lot of money into surface mount technology, but when I talk to customers, I just don't hear their name very often. I hear Sprague, Kemet and AVX more." Indeed, AVX is also planning for sales growth in excess of 20% this year. Admits Karlik: "We still have a ways to go to get the Mepco/Centralab name on the tip of the user's tongue."

ALDEN M. HAYASHI

ARTIFICIAL INTELLIGENCE

Expert systems on the factory floor

Most AI R&D is going on behind closed doors. But progress is being made, experts on expert systems say

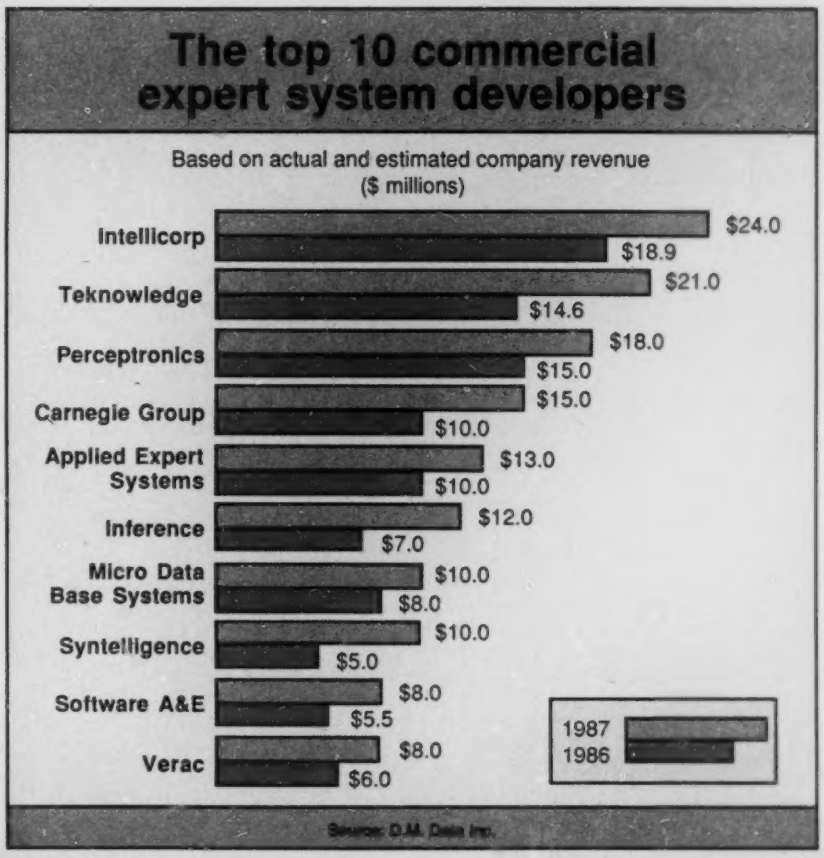
By Mary Jo Foley

Expert systems — software that enables computers to reason like humans — is the most common form of artificial intelligence, but most of the development work is taking place behind closed doors in *Fortune* 500 companies. Much of the work is occurring at electronics factories and is focused on finding applications in the manufacturing environment.

Paul Harmon of the San Francisco-based consultancy, Harmon & Associates, estimates that there are already 1,000 manufacturing expert systems under development at electronics and other U.S. corporations. Existing applications range from growing gallium arsenide crystals for semiconductor production, to repairing and configuring electronic equipment.

Relatively few of these systems, however, are expected to become commercial products; those which do are much more likely to be embedded in existing hardware and software offerings than sold as off-the-shelf packages.

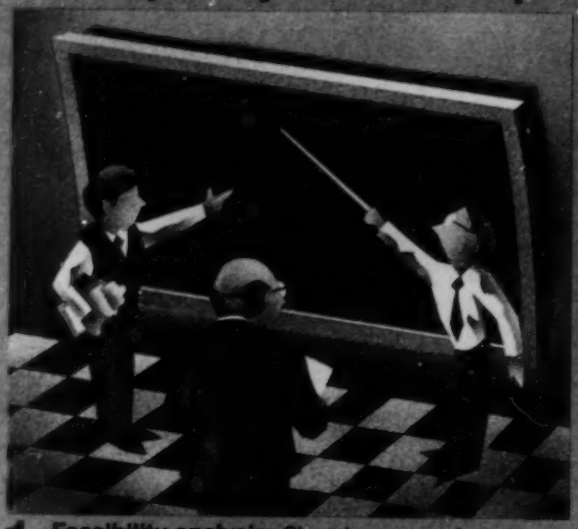
Instead, the vast majority of manufacturing-oriented expert systems will be used internally by companies to achieve and maintain competitive advantages in their respective businesses. In terms of tangible benefits, expert systems for manufacturing "create opportunities for increased productivity, reduced costs [as a result of less machine down-time], shortened design cycles, improved utilization of people assets, and improved [product] quality," explains Mark Linesch, product marketing manager for AI software within Texas Instruments Inc.'s Data Systems Group. Ultimately, industry gurus say, manufacturing expert systems could prove to be the glue which will bind the individual automated manufacturing processes that comprise the computer-integrated manufacturing factories of the future.



THE MARKET

Most credit the General Program Solver — a program designed to prove the validity of Principia Mathematica, the early 20th century propositional calculus system, which two Carnegie-Mellon University researchers devised in the late 1950s — as the first expert system effort. The developers demonstrated a working prototype at the now-famous

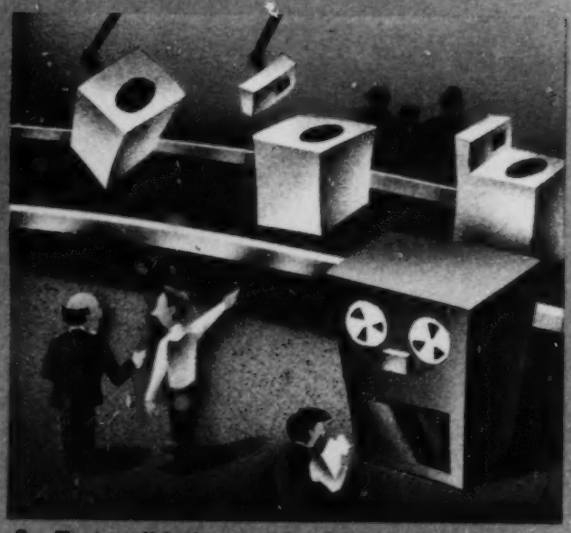
The expert system development cycle



1. Feasibility analysis: Choosing a manufacturing problem to which expert system technology is applicable and provides the best solution is the most crucial issue in expert system design.

2. Knowledge acquisition and engineering: Extracting information from various sources (including human experts) and inputting it into the expert system can be a long and involved process.

3. Prototype development: Making additions, changes and deletions to the various pieces of the expert system is key to honing its problem-solving capabilities.



4. Test, validation and implementation: Integrating the expert system with other manufacturing hardware and software is probably the most difficult step in the expert system development process.

Dartmouth Conference, held at Dartmouth College in Hanover, N.H., in 1956. Following the conference, several researchers honed their expert system knowledge by developing systems which played championship-level chess and checkers. One of the first, if not *the* first, true expert system success stories came into being shortly thereafter: Stanford University Professor Edward Feigenbaum's Dendral, a system for analyzing chemical compounds.

Today, according to the Scottsdale, Ariz., AI market research firm, D.M. Data Inc., expert systems represent one of the largest segments of the AI market. Of the $1.43 billion spent in 1987 on AI development in the United States, D.M. Data projects that $225 million, or 16% of the total, is attributable to expert systems this year. By 1990, when the total market reaches $4.05 billion, the expert system portion will reach $810 million, or 20% of the total, claims analyst Harvey Newquist.

But, because these estimates reflect commercial sales of AI hardware and software, they do not take into account most of the substantial in-house investments companies are making in AI. For this reason, it is difficult, if not impossible, to make estimates of the true size of the expert system world.

Most industry watchers do agree, however, that the lion's share of activity in most AI segments — expert systems included — still is defense-related. One such analyst, Peter O'Farrell of Arlington, Massachu-

Dave Joy

TI's MARK LINESCH: Expert systems for manufacturing "create opportunities for increased productivity"

setts-based Cutter Information Corp., claims the defense portion of the expert system market represents two-thirds to three-fourths of the total investment. Of the remaining portion, the manufacturing expert system segment is the largest, comprising about 12% to 15% of the "commercial" expert system world, O'Farrell says. The second largest commercial area is financial/banking, at 8% to 10%, he estimates.

"This year, things probably will be slowing down a little. It's time for contemplation and absorption of existing technology," says O'Farrell, who also is coauthor of a recent Cutter study entitled "Expert Systems in Manufacturing."

Nonetheless, operational expert systems for manufacturing abound and should continue to proliferate. The first such systems evolved as joint projects between top universities and their neighboring high-tech companies, such as the Massachusetts Institute of Technology and Digital Equipment Corp.; and Carnegie-Mellon University and Westinghouse Electric Corp. Some expert systems for manufacturing, such as DEC's XCON, a program which configures all DEC computers, have achieved legendary status in the worldwide AI community. Others, such as AT&T's switch-failure detector, which is being developed by engineers at its Oklahoma City 5ESS switch manufacturing facility, are relatively unknown.

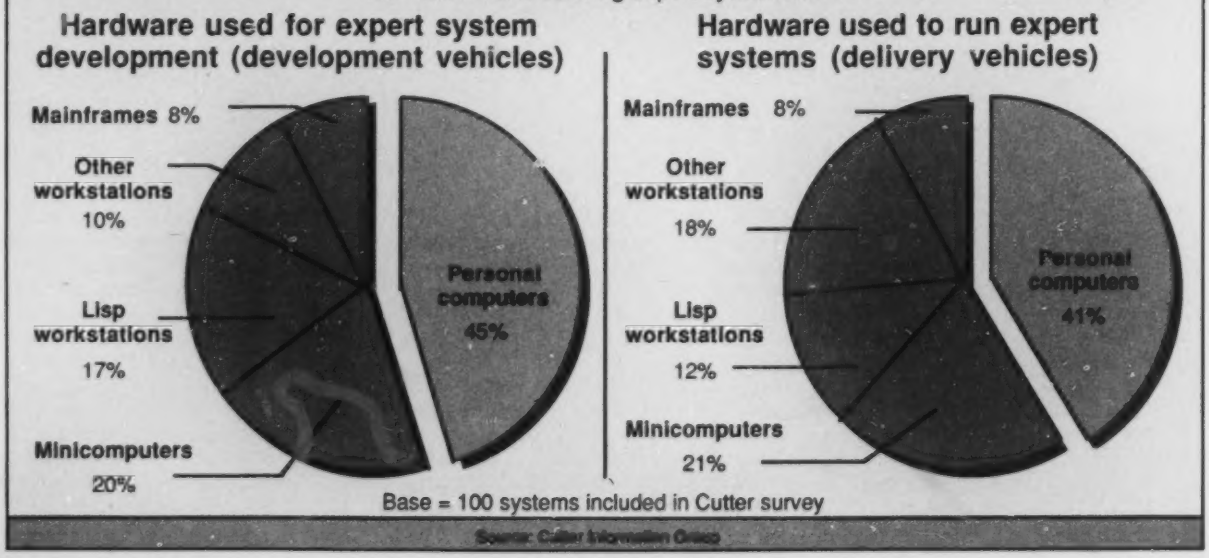
Despite their wide-ranging applications, some commonalities do exist among expert systems for manufacturing. Like more traditional manufacturing software, expert systems for manufacturing tend to be modular in design — meaning they are comprised of interlocking individual modules, as opposed to being massive, single programs. One way to segment these systems is to divide them according to which step, or steps of the manufacturing process they address. Typically, these steps include: Product specification; design; planning; production; distribution; field service; and project management.

Of these areas, design, production, and field service, are where most of the expert systems for manufacturing to date have been developed and deployed.

Several of the largest U.S. electronics companies are known to be running multiple expert systems in one or more of these three segments. Among them are AT&T, DEC, Hewlett-Packard Co., Honeywell Bull Inc., Ford Motor Co., General Motors Corp., Hughes Aircraft Co., IBM, NCR Corp., Texas Instruments, Un-

Users favor micros for expert system development and delivery

1987 U.S. manufacturing expert system market



Base = 100 systems included in Cutter survey

Source: Cutter Information Group

Peter Silva/Picture Group

isys Corp., Westinghouse and Xerox Corp. In Japan, Fujitsu Ltd. and Hitachi Ltd. are the manufacturing expert system pioneers.

A whole other set of much smaller companies also are part of the expert system world. These are firms whose entire businesses are geared toward providing expert system software and related consulting/educational services. Most of these companies sell expert system development tools and "shells," or software frameworks upon which customers may build customized expert systems. A handful of these smaller vendors offer completed expert system application packages.

Based on estimated 1987 revenue, D.M. Data says the top five companies in this category are: Intellicorp, Mountain View, Calif.; Teknowledge Inc., Palo Alto, Calif.; Perceptronics Inc., Woodland Hills, Calif.; Carnegie Group Inc., Pittsburgh, Pa.; and Applied Expert Systems Inc., Cambridge, Mass. In several cases, the big-name electronics vendors are the primary investors and/or major customers of these expert system software firms. DEC, TI, and Ford, for example, back Carnegie Group; Ford and Lockheed Corp. are key investors in Inference Corp.; and Control Data Corp. provided initial funding for Software Architecture & Engineering Inc.

COST OF ENTRY

Until fairly recently, expert system technology was prohibitively expensive. Now, with expert system development packages priced from $99 (Paperback Software International's well-received VP Expert), to hundreds of thousands of dollars for the top-of-the-line expert system shells and applications, there truly is something for everyone who wants to experiment with the technology.

In theory, at least, all a customer needs to create an expert system is access to a computer and a copy of a programming language — such as Lisp, Prolog or another AI language; or C, Fortran or any of the other more traditional ones. In practice, however, companies are likely to find that even though their potential payback is great, expert systems for manufacturing are among the most costly expert systems to develop and maintain. Such systems require a lot of customization, such as the development of interfaces between the software and manufacturing equipment. Many times, however, this means calling in an AI consultant.

The cost of hardware used to develop and run expert systems for manufacturing also varies greatly. Machines ranging from $5,000 IBM PC ATs; to $100,000 symbolic processors (also called Lisp machines); to $1 million parallel processors; all can, and have been, used as expert system "development" and "delivery" vehicles. In AI jargon, the hardware on which expert systems are developed is called a development vehicle; the hardware on which the expert system runs is the delivery vehicle.

Most expert system developers today are spending between $1,000 and $5,000 on their expert system development software

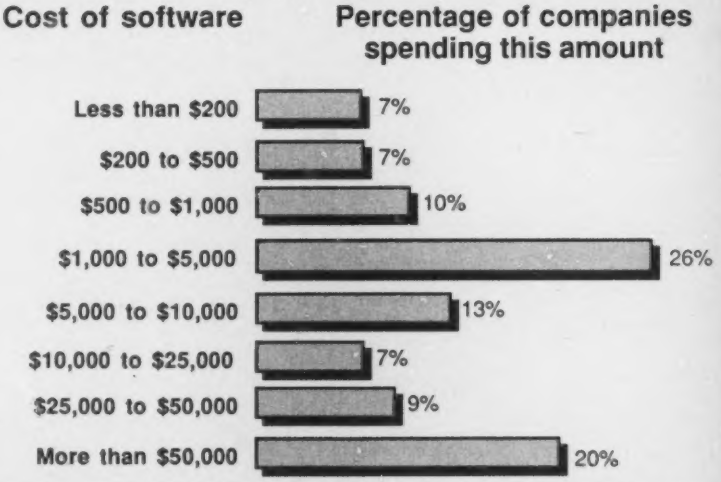
Currently, the most common expert system development and delivery environments are personal computers. These are followed by minicomputers and then workstations — both Lisp-based and others, for instance, those of Apollo Computer Inc. or Sun Microsystems Inc., according to a recent survey by Cutter Information. Additionally, most expert system developers today are spending between $1,000 and $5,000 on their expert system development software. The second most frequent expert system software-expenditure category cited by respondents to Cutter's survey was more than $50,000.

One expense which has not varied the way hardware and software product prices have, is software development costs, measured in terms of programmers' salaries and time. An average estimate of current non-AI software development costs, in man years, according to several software houses, is $120 million per man year.

Programmers skilled in AI development are in high demand and thus command higher-than-average salaries: $30,000 to $60,000 plus, according to AI Consultants in Somerville, N.J. And "knowledge engineers" — individuals responsible for obtaining information from written and human sources and molding it to form a

Software spending is on the rise among companies developing expert systems

1987 software expenditures for expert system projects*



*Expenses counted are software languages, tools, and applications that companies use to create customized manufacturing expert systems. Not included are software packages not used specifically for expert system development, and consulting fees beyond those included in the original software cost.

Base = 100 systems included in Cutter survey

Source: Cutter Information Group

knowledge base — are even more scarce and expensive. TI, Unisys, Teknowledge, and a handful of other companies are attempting to lessen AI programmer shortages by making available written, video and satellite AI courses and seminars. Yet, as the vendors themselves would admit, these educational materials never will take the place of hands-on experience.

D.M. Data estimates that expert system shells and other programming tools can cut expert system development time by as much as 50%. Yet most expert systems can still take many months or years to develop. "Most people say you should start small and always expect the system to require more resources than you originally planned," Cutter's O'Farrell adds.

There are some well-known success stories. Ford's Dearborn, Michigan-based Robotics and Automation Applications Consulting Center, developed a 120-rule system using TI's Personal Consultant in 16 man weeks at a total estimated cost of only $5,000. The system, known as Maintenance Assistant, aids technicians in repairing ASEA robots which are used in applications ranging from welding to assembly, throughout Ford. It has been so successful that Ford has urged other robot makers to embed similar diagnostic expert systems in their products.

Usually, however, the cost of entry runs on the high side. Internally at TI, for instance, nearly every division is working to integrate AI hardware and software into their day-to-day manufacturing processes, says marketing manager Linesch. TI engineers have developed many applications — including fairly complex ones, such as TI's diagnostic system for its epitaxial reactor, a machine responsible for applying thin-film coatings to silicon slides. That system uses TI's Personal Consultant software on TI microcomputers and costs about $10,000. But even fairly small and

An expert system primer

Expert systems are what most people think of when they hear the words "artificial intelligence." The two are not synonymous, however. Expert systems are software programs which enable computers to draw conclusions and "reason," similar to the way people do. Just like natural language, machine vision, and voice recognition systems, expert systems are a subset of AI. Unlike these other segments, expert systems already have been deployed on a wide scale.

Another way to understand expert system technology is to look at it in terms of programming. While standard software programs use step-by-step, predetermined procedures to solve problems, expert systems are created using facts, rules of thumb (heuristics), and other information particular to a certain domain. Rather than crunching numbers, computers which run expert systems process ideas or symbols (hence the term "symbolic processing," which many use when referring to AI). They do this primarily by comparing strings and alpha-numeric characters, and then joining, separating or substituting them.

No matter which industry they come from or where they are used, and regardless of their size or complexity, all expert systems share some basic characteristics. All consist of three primary parts: the knowledge base; the inference engine; and a user interface.

The knowledge base consists of declarative knowledge (information on known, predetermined objects, events and situations) and procedural knowledge (information on possible choices of action). These two types of information may be separate or integrated, depending on the type of knowledge-representation scheme chosen to access the information.

EXPERT SYSTEMS are software programs which enable computers to "reason"

In many cases, it is the inference engine which selects this scheme. The inference engine determines which "rules," or clusters of information, are relevant; accesses these rules; and determines when the appropriate solution to a particular problem has been found. Two terms regularly applied to inference-engine reasoning are forward chaining and backward chaining. The former implies that the system is attempting to reason from facts to a solution; the latter means the system is working from a hypothetical solution to find facts supporting it.

The user interface is probably the least developed part of expert system technology, at least according to the users. Often based on technology from another AI discipline — natural language, which is the capability of systems to comprehend user commands expressed in the user's everyday language rather than structured programming language — the user interface is the layer of software which enables nonprogrammers to interact with an expert system. Ultimately, voice systems, too, could become a part of many expert systems.

Expert system "shells," along with other development tools, can help users write expert systems by giving them a framework upon which to build their knowledge bases. Most shells are either rule-based: following an "if-then" sequence; or frame-based: basing its reasoning on previous examples. To date, the majority of commercially available shells have been fairly generic; that is, they have consisted primarily of skeletal inference engines and user interfaces. Gradually, the top shell vendors are introducing domain-specific shells — some geared toward horizontal applications, such as production planning shells; and others vertically focused, such as financial/banking shells. □

simple expert systems can take six to eight months to develop, resulting in total expenditures of $50,000 or more, Linesch says. Larger expert systems for manufacturing, such as the scheduling system for flexible manufacturing, which is in use at TI's Trinity Mills facility, easily run into many years and "hundreds of thousands of dollars," he admits.

THE OBSTACLES

Theoretically, the steps to building an expert system are fairly straightforward. First, a customer, usually with the help of one or more AI professionals, chooses an application area which the system will address. At this point, the user usually also selects the computer hardware and software which will be used to develop the expert system. One or more "knowledge engineers" then engage in what commonly is called knowledge engineering, or extracting information from various sources (including human "experts") and inputting it into the system.

The inference engine — the software which structures the expert system's knowledge — is then added to this knowledge base, resulting in a prototype expert system. The customer tests the prototype, and makes revisions by adding, changing or deleting information. The system is then retested. Once this process is complete, the system is ready to go.

On paper, of course, all this looks simple. But seldom does expert system development proceed smoothly — especially in the manufacturing segment. Integration of all types of AI technologies into non-AI based environments continues to pose a major hurdle. In a factory, for example, awkward questions arise time and time again. For instance: What type of hardware is best suited to running the system, and is there a Lisp and/or C compiler available for it? Can the expert system handle standard network protocols, such as those which are part of Ethernet; TCP/IP, a defense networking protocol; or Manufacturing Automation Protocol? How can the expert system interface directly with sensors; multiple vendors' design, production, and test equipment; and other software, such as database and MRP systems?

TI's Linesch notes that TI has attempted to stave off some of these difficulties by embedding expert systems into such factory-floor devices as programmable controllers. It also has introduced a C-language version of its PC Plus development package, and is in the process of determining the feasibility of converting knowledge bases into C. And in July, it released Personal Consultant Online, an add-on package which enables users to build expert systems which interact directly with industrial processes by providing multiple interfaces to existing data acquisition and analysis programs.

Another vendor, Gensym Corp., a Cambridge, Mass., start-up which is marketing a real-time expert system development product, has attacked these integration problems by building a system which is specific to the manufacturing environment. Its G2, which was in beta test at four companies as of early September, is a self-contained tool, complete with windowing interfaces, networking, gateways, and simulation capabilities.

In addition to these technical considerations, "people issues," such as building user confidence in the expert system, maintenance and training, are also oftentimes seen as obstacles for expert system vendors and users. Cutter's O'Farrell says some of the most pressing people-related obstacles are:

- Achieving a basic understanding of AI technology. ("Just because you've written things in Fortran doesn't mean you can write an expert system," he says);
- Finding an AI "champion" in your company and then winning support of middle management for your AI project;
- Calculating the potential benefits of your expert system, and proving to management's satisfaction that these benefits will be realized;
- Convincing users (especially non-managers) to use and trust the expert system;
- Having adequate access to the expert or experts from whom you intend to draw the knowledge to create the system; and
- Appreciating fully the effort and time which will be required to develop a truly useful expert system.

AI microprocessors

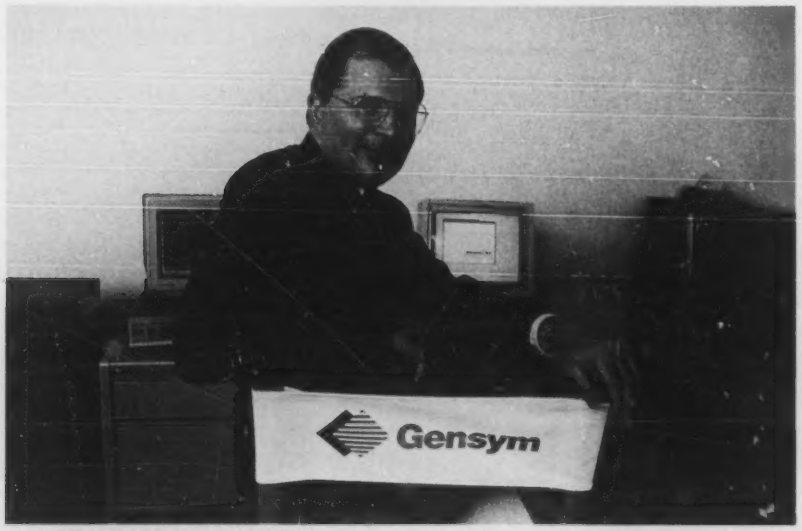
Company	Intel	TI	Symbolics
Part	80386	MegaChip	Ivory
Type	32-bit	32-bit	40-bit
Equivalent transistors	275,000	553,687	400,000
Technology	Double-metal CMOS	Double-metal CMOS	Double-metal CMOS
Resolution	1.5 microns	1.2 microns	1.5 microns*
Die area	152,00 sq. mils	160,000 sq. mils	202,500 sq. mils*
Pins	132	264	144
Package	Ceramic	Ceramic	Plastic
Factory cost (estimated)	$55	$110	$60

Currently, all types of microcomputers, minicomputers, mainframes and symbolic processors are used as both development and delivery vehicles for expert systems. But the new generation of microprocessors, listed above, promise to narrow the development-delivery gap as well as the AI-DP gap. Comments D.M. Data Inc.: "It will be interesting to note how each of these chips fare; not only as the basis for particular machine architectures, but most especially as coprocessors and components for add-on boards. Since there is already talk of an Intel AI-based 80486 processor, and RISC chips are showing up in engineering workstations, each of these chips will have to prove their worth within a two-year timeframe."

*After die shrink. Source: D.M. Data Inc.

THE COMPETITION

Only a handful of electronics companies have attempted to go commercial with their expert system technology. And those which have, seem to be consciously limiting their participation. For example, NCR recently completed the first expert system based on the Proteus expert system shell designed by the participants involved in the Advanced Computer Architecture Program at the Austin, Texas-based research consortium, the Microelectronics & Computer Technology Corp., otherwise known as MCC. The system, Design Advisor, will aid NCR engineers in designing semiconductors. NCR says it also will offer the product to its customers. It will be priced somewhere between



GENSYM's LOWELL HAWKINSON: "The major issue [in manufacturing] is handling things in real time"

Ted Fitzgerald

$4,000 and $8,000 and will run on Symbolics Inc. and Apollo hardware only.

"Most manufacturers are still in the learning and prototype stages," agrees Peter Pennisi, director of knowledge systems marketing for Unisys.

Even though the Detroit-based Unisys has developed a printed circuit board fault-diagnostic expert system and a just-in-time mainframe manufacturing one, it intends to keep both systems proprietary, Pennisi says. Instead, like DEC, TI, Xerox, and others, it is concentrating its commercialization efforts on expert system development tools, educational materials, and, in Unisys' case, hardware (in the form of Explorer Lisp machines which it purchases on an OEM basis from TI). For the long run, Pennisi says, "we're working on adding and embedding intelligence into software we already have, especially the manufacturing software we sell into vertical markets." Unisys also is continuing to evaluate the possibility of selling expert system shells (called Power Packs by the former Sperry Corp.) for specific vertical markets.

Some market watchers consider Operations Advisor from Palladian Software Inc. to be the first complete manufacturing expert system application package. But the hottest competition in expert systems for manufacturing is occuring these days in the expert system shell arena. Very few manufacturing-specific shells exist; in fact, some industry watchers say that Picon, a real-time product developed by Lisp Machines Inc. (now part of Gigamos Holdings of Montreal, Canada), and the recently introduced G2 from Gensym, are the only ones on the market. Gigamos and Gensym currently are involved in litigation regarding the rights to the Picon technology.

"The major issue [in manufacturing] is handling things in real time," [illegible] out Lowell Hawkinson, chair[illegible]and chief executive of Gensym. "Ye[illegible]lmost all of the existing expert syst[illegible]m tools and shells are more suited to more static kinds of problems. They almost never have significant development of time-based reasoning."

Despite these deficiencies, the more generic expert [illegible]stem shells — from vendors such as the Carnegie Group, Inference Corp., Intellicorp, Software Architecture & Engineering and Teknowledge Inc. — are finding their way into manufacturing expert system development at many electronics companies. The demand for these products should increase even further, since within the past two years, vendors have made them available in C and/or Lisp, rather than Lisp only. (Intellicorp is the sole major vendor which sells only Lisp versions of its products. Teknowledge, on the other hand, sells C-based software only.) The migration toward C was spurred by customers' needs to integrate their AI applications with non-AI ones.

This kind of integration is not easy, however, as has been proven by past experience at Los Angeles-headquartered Inference. Inference attempted to recompile in C a symbolic processor-based Lisp version of its ART software product for the DEC VAX. It released the resulting product in April and promptly sold 60 copies. But there were so many bugs in it, the company concedes, that Inference was forced to pull it from the market. It is now reimplementing Lisp versions of ART for the VAX using commercially available VAX Lisp compilers — packages which were not available when the company made its initial decision to go with C.

Despite all the trouble, the move toward VAX and C has been worth it for Inference, according to Abraham Gutman, assistant to the president. Between 25% and 40% of the 600 copies of ART installed worldwide are being used to develop expert systems for manufacturing, he says.

Until the past year or so, "there was a tendency among industrial engineers to see AI as too difficult. As a result, AI was introduced slowly in areas like monitoring, rapid diagnosis, and process planning," Gutman explains. Now, however, companies are "moving away from academic diagnosis, maintenance, and configuration [concerns]." The new question which companies are trying to solve via expert systems for manufacturing, Gutman claims, is: "How is it we can improve the planning process?"

Another tack a number of the expert system shell vendors are taking to make their products easier to integrate into real-world applications is the introduction of domain-specific shells. The Carnegie Group, for one, will introduce two "class-specific" development shells within the upcoming few months, according to manager of sales, Jay Leasher.

By the end of 1987, Carnegie also plans to make available a tool which will enable customers to develop diagnostic-type expert systems more rapidly. The tool will be available in two versions: one for development, initially for TI Explorers; and one for delivery, for IBM PC AT and DEC MicroVAX systems. The other shell, which Carnegie Group expects to begin shipping in the second quarter of 1988, will aid customers in building discrete-event modeling and simulation expert systems. It most likely will be available for the MicroVAX and possibly some other workstations, Leasher says.

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IBM had its electronics *glasnost*. Is it Japan's turn now?

To remain competitive, Japanese companies should become less vertically integrated. An opportunity for the U.S.?

By Alberto Socolovsky

There was a time when IBM looked like Fujitsu looks today. Two decades ago, IBM made a lot of its own components and subsystems, as do Fujitsu and many other systems manufacturers from Japan. These Japanese companies go a step further by selling them too.

The model — vertical integration to increase value added within the company or to enhance proprietary technology — worked for IBM, but not for dozens of U.S. electronics companies which tried to copy it on the assumption that what was good for IBM was also good for the rest of the electronics industry. The model did work for the Japanese electronics industry, which was under different financial constraints than its U.S. counterpart.

Today, however, IBM looks more like its smaller competitors: less vertically integrated, more dependent on the rest of the industry. The world's No. 1 computer manufacturer is undergoing an electronics *glasnost*, openness toward companies it would have considered competitors only 10 years ago, and openness toward components suppliers which at one time used to worry about disclosing their technology lest it wind up in Big Blue's internal production.

The difference between vertically integrated Japanese companies and the increasingly concentrated American ones is best evidenced by comparing the ratio in revenue per employee for both countries. There is hardly a difference in Japan among components and systems manufacturers, whereas in the United States, the productivity of a profitable computer manufacturer such as Apple Computer Inc. is more than five times larger than its microprocessor supplier, Motorola Inc. The reason is that Apple couldn't possibly make microprocessors profitably, while Motorola can make them and be profitable at a much lower level of revenue per employee.

Now that Japan's financial structure is changing as the yen finds its rightful value among the world's merchant currencies, Japanese companies may find that *glasnost* is not just for IBM. And, when they look for suppliers that can be both profitable and help them make a profit, they should look first in the United States.